STATISTIKA

STATISTICS AND ECONOMY JOURNAL

VOL. **96** (1) 2016

CZECH STATISTICAL OFFICE

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Czech GDP between 1970 and 1989 Based on ESA 2010

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Abstract

Long time series of the main macroeconomic indicators are in demand by researches and economic experts. The Department of Economic Statistics from the University of Economics in Prague reconstructed the historical time series of GDP and its components in ESA 1995. Thus, we interpreted economic development of the Czech Rep. Between 1970 and 2013 based on ESA 1995. In 2014 the Czech Statistical Office recalculated national accounts since 1990 using the newly adapted European standard of accounts 2010. Introducing ESA 2010 brought the need to recalculate the historical time series into this new standard. The paper aims at describing the main adjustments in this recalculation and presenting the main results of expenditure and production approaches to GDP. Since the most important changes in the standards concern capitalisation the most significant changes affected gross capital formation.

Keywords

Gross domestic Product, Gross value added, Material Product System, ESA 1995, ESA 2010

JEL code

E01, C02, N01, O4

INTRODUCTION

For the purpose of an economy analysis researchers need long time series of the main economic indicators. Until 2014, researchers had at their disposal the time series of the gross domestic product (GDP) and its components according to the European standards of accounts ESA 1995 (Eurostat, 1996). Data for the period between the years 1970 and 1989 were compiled by the researchers from the Department of Economic Statistics at the University of Economics in Prague. The time series since 1990 is published by the Czech Statistical Office (CZSO) as the part of the national accounts official figures. The methodology of the transformation of the indicators published originally according to the Material Product System (MPS) was described in detail in Sixta and Fischer (2014) and Fischer et al. (2013). It corresponds

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to the works presented by Arvay (1992) and United Nations methodological papers (UN 1977 and UN 1981).

In 2014, a new methodological standard, ESA 2010 (Eurostat, 2011), was implemented by national statistical offices. ESA 2010 brings several adjustments in the calculation of GDP and its components. The capitalisation of expenditures on research and development, the capitalisation of expenditures on weapons and the capitalisation of expenditures on small tools represent the main modifications. Moreover, ESA 2010 introduced changes in sector classification, employee stock options, payable tax credits or FISIM between resident and non-resident financial institutions (for detailed information see Eurostat, 2014). Since we focused on the issue of gross domestic product, only selected methodological changes were taken into account. This implementation caused an inconsistency in the time series of the main Czech macroeconomic indicators. While the CZSO publishes macroeconomic indicators from 1990 onwards in ESA 2010 the first part of the time series was published in ESA 1995. The purpose of our project is the recalculation of the historical time series according to ESA 2010.

The aim of this paper is the description of the main methodology changes from ESA 1995 to ESA 2010 and the recalculation of the historical data. Moreover, we present main results gained for the expenditure and production approaches to GDP. Even though we prepared these estimates on the basis published aggregated data, in principle we respected the approach usually used in official statistics. For the cases of research and development and military weapons, we were able to work with real data, see below. The case of small tools was rather more difficult with respect to changing accounting environment and the estimates are based on model approach. Primary data and in many cases aggregated data were inevitably lost during the transformation of Czechoslovak statistics and the rest of them during floods in 2002. Despite these difficulties, we tried to prepare data to be fully consistent with the figures officially published by CZSO for the Czech Republic.

1 DATA AND METHODOLOGY

The methodology of the composition of historical time series of the Czech GDP was described in detail in Sixta and Fischer (2014). This paper focuses on the description of main methodology changes from ESA 1995 to ESA 2010 and its impact on the historical numbers. The most important changes in terms of GDP relate to the capitalisation of expenditures on research and development (R&D), the capitalisation of expenditures on weapons and the capitalisation of small tools. All these changes are connected with the definition of an asset.

The capitalisation of expenditures on R&D reflects changes in society. Such expenditures are expected to bring benefits in the future. Purchases of R&D services and individual expenditures on intermediates, compensation of employees and consumption of fixed capital are regarded as capital formation. In practice, it is recorded similarly to other output for own final use. Data of R&D are not surveyed directly. They are estimated as national accounts adjustment which SNA 2008 regards one of the most important modifications. It represents a significant change that leads to an increase of GDP values. The estimations of the historical data were prepared according to the recommendations described in Eurostat (2014). We use data on current expenditures from statistical Yearbooks 1973–1992 and Selected Indicators of the Balance of Sources and Uses of Global Product and National Income 1980–1985 (CZSO, 1987).

The capitalisation of expenditures on weapons divided noticeably into military and non-military investment. Based on ESA 1995 the purchases of military aircraft and other weapons were treated as intermediate consumption. With ESA 2010 the perception changed. Weapons should provide defence services and the impact of weapons is measured by consumption of fixed capital (CFC) of weapons. For the reconstruction of the historical time series we had to find data for the period between 1970 and 1989 to construct capital formation. Consumption of fixed capital was estimated according to the Perpetual

Inventory Method (PIM).[5] Since data were available for Czechoslovakia only, CFC split between the Czech Republic and Slovakia with the proportion of two thirds to one third, respectively. It corresponded to the procedures used by statisticians in Czechoslovakia in such cases.

The last mentioned adjustment occurred from the updated definition of gross fixed capital formation. This arises from the ESA 1995 act stating that all purchases of small tools with the value lower than 500 ECU in 1995 prices are treated as intermediates (Eurostat, 1996). ESA 2010 dropped this limitation. The only relevant condition for recording capital formation is the usability of small tools for longer time than one year in the production process. This issue is closely connected with accounting procedures in the economy. When CZSO prepared the revision of national accounts, this adjustment presented one of the most important parts among all adjustments. This arises from the relative rigidity in the rules of the income tax law and constantly decreasing prices of electronic devices. Since it was practically impossible to find historical data for small tools, we used the average percentage to decrease intermediate consumption (1.2% of intermediate consumption).[6]

Table 1 shows the impact of all the mentioned adjustments on GDP. Apparently, the capitalisation of research and development represented the most significant impact in the period between the years 1970 and 1990 (it caused the increase of GDP by 2.22% in 1970 and 2.11% in 1980). Since 1990 the impact of the capitalisation of small tools has become the important one (1.66% of GDP in 2010). With respect to the economic development of the Czech Republic in 1970s and 1980s, the changes given by R&D are more important. One of the possible explanations lies in the approach to research institutes with sufficient number of workers and overall amount of paid wages. As expected, the implantation of ESA 2010 affects mainly the "level" of GDP rather than growth rates. Therefore, there are only visible long term tendencies. The changes connected with transformation of the economy are also reflected in increased purchases of small tools (including computers), dissolution of research institutes etc.

Table 1 Impact of inclusion of selected adjustments on GDP, %

	1970	1980	1990	2000	2010
Capitalisation of research and development	2.22	2.11	1.12	1.33	1.20
Capitalisation of weapons	0.17	0.15	0.88	0.25	0.16
Capitalisation of small tools	1.50	1.63	2.76	1.23	1.66
Total	**3.89**	**3.89**	**4.76**	**2.81**	**3.02**

Note: The figures in the table were calculated as a share of each methodical adjustment on GDP in ESA 1995.
Source: Czech Statistical Office, authors' calculation (1970–1989)

There are more methodology adjustments which influenced sources and uses of GDP. They include other adjustments given by the new national accounts standards ESA 2010 and various improvements prepared by statisticians. Due to a lack of data sources we could not manage to estimate adjustments with a limited impact on GDP (e.g. dwelling services, insurance services etc.). Table 2 presents the impact of all adjustments on GDP. The impact of other adjustments represents 0.7% of GDP in the period between 1970 and 1989. Since 1990 their impact increased up to 1.6%.

[5] We would like to thank Dr. Martina Němečková from the Czech Statistical Office for her support and estimates of consumption of fixed capital on military equipment.

[6] Apparently, it is a very simple method. However, due to the comparability of our and official estimates it is necessary to calculated it this way. With respect to accounting rules in socialism. The investments thresholds were about 3 000 or later 5 000 CSK by 1993.

Table 2 Impact of all adjustments on GDP, mil. CSK/CZK, %

	1970	1980	1990	2000	2010
GDP ESA 1995	292 954	459 247	632 691	2 269 695	3 775 237
GDP ESA 2010	306 431	480 605	672 776	2 372 630	3 953 651
Adjustments	13 477	21 358	40 085	102 935	178 414
- Selected (R&D, weapons, small tools)	11 381	17 862	30 171	63 815	113 918
- Other	2 096	3 496	9 914	39 120	64 496
Total GDP increase, %	4.6	4.7	6.3	4.5	4.7

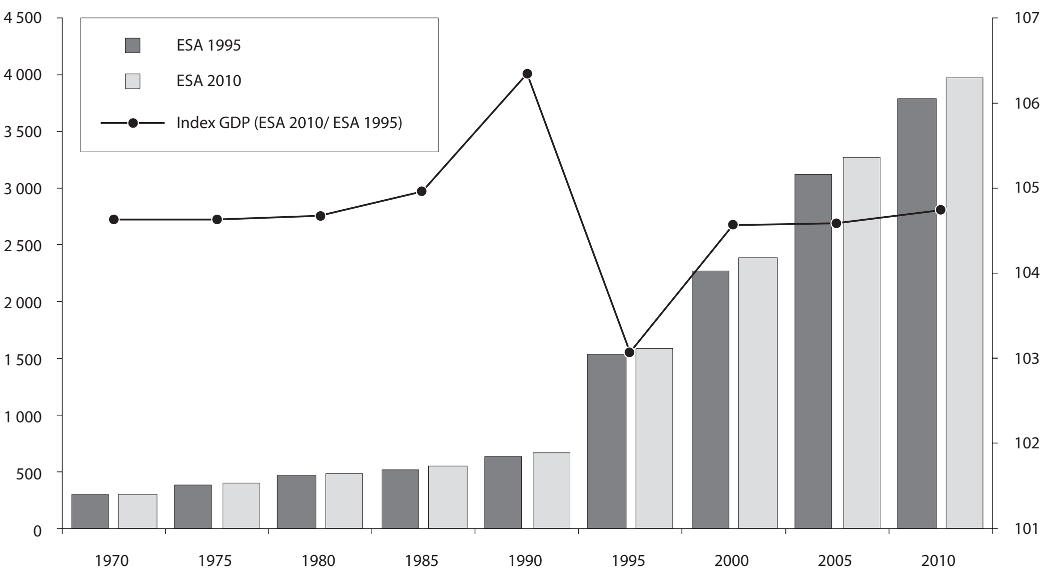
Source: Czech Statistical Office, authors' calculation (1970–1989)

2 RESULTS

The first results of our project consist of production and expenditure approaches to GDP, i.e. it covers sources and uses of GDP. Presented values are balanced and compiled according to the ESA 2010 methodology. The process of calculation ensured consistency with the officially published data by CZSO from 1990 onwards. Thus, the time series of GDP and its components from 1970 to the present should be free of methodological inconsistencies and time series breaks.

Figure 1 shows the comparison of GDP using ESA 1995 and ESA 2010 methodology. No significant differences in the development at current prices occurred. This applies mainly to the period between 1970 and 1990. This is caused mainly by the fact that the latest updates of ESA were connected with the knowledge based economy. Effects given by new statistical issues as small tools and R&D expenditures compensate each other. Therefore, methodological adjustments rarely play an important role in the estimates of real growth.

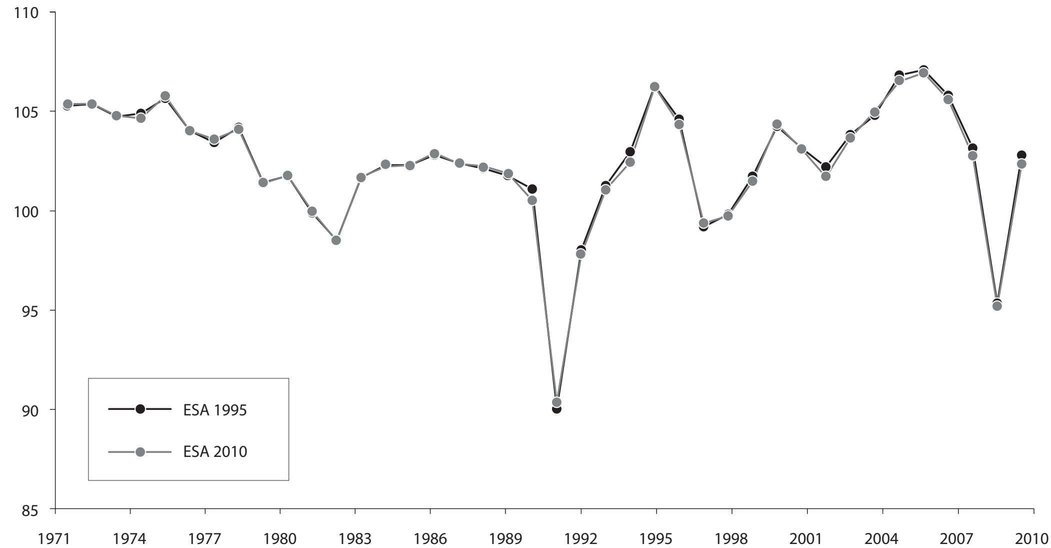
Figure 1 Comparison of GDP between ESA 1995 and ESA 2010 methodology, current prices, 1970–2010, bn. CSK/CZK



Source: Czech Statistical Office, authors' calculation (1970–1989)

Figure 2 presents volume indices. Apparently, methodological adjustments have no impact on the real development with the most significant drops in 1982 (1.5%) and 1991 (10.0%).

Figure 2 GDP, volume indices, 1970–2010



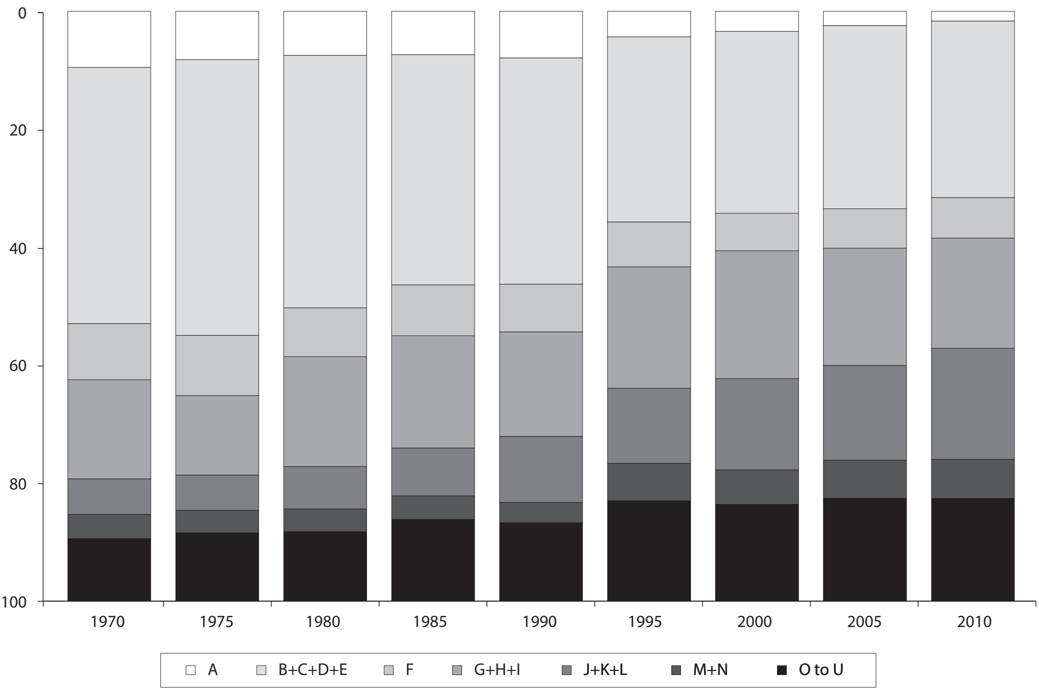
Source: Czech Statistical Office, authors' calculation (1970–1989)

2.1 Production approach

Gross value added (GVA) brings the most valuable data within the *production approach*. The picture of the economy reflects the currently used industrial classification of NACE rev.2. Figure 3 presents the significant change of the structure of Czech economy between the years 1970 and 2010. The changes were fundamental and the current economy is based on radically different foundations than 40 years ago. The most significant is the decrease of the share of agriculture (A) from 9.5% in 1970 to 1.7% in 2010. Similar development occurred in manufacturing, electricity and water supply and mining; the share of these industries (B to E) decreased by 13.5 p.p. between the years 1970 and 2010. On the other hand, the share of services such as information and communication, financial and insurance activities and real estate activities (J to L) increased by approximately 13 p.p. While in 1970 the GVA of these industries constituted 6.0% of the total GVA, in 2010 it reached 18.9%.

Table 3 shows the changes from ESA 1995 to ESA 2010 concerning GVA broken down by industries. The adjustments mainly changed services such as communication and financial activities. Involving the adjustments decreased the amount of these industries by approximately 5%. On the contrary, in the year 2000 and 2010 the GVA of communication and financial activities (J to L) increased by 18.9% and 14.3% respectively. The impact of research and development is very significant between 1970 and 1990. It is mainly recorded in the industry of Professional, Scientific and Technical Activities (M).

Figure 3 Gross value added in ESA 2010 broken down by industries (CZ-NACE), %



Source: Czech Statistical Office, authors' calculation (1970–1989)
Note: A = Agriculture, Forestry and Fishing; B = Mining and Quarrying; C = Manufacturing; D = Electricity, Gas, Steam and Air Conditioning Supply; E = Water Supply; Sewerage, Waste Management and Remediation Activities; F = Construction; G = Wholesale and Retail Trade; Repair of Motor Vehicles and Motorcycles; H = Transportation and Storage; I = Accommodation and Food Service Activities; J = Information and Communication; K = Financial and Insurance Activities; L = Real Estate Activities; M = Professional, Scientific and Technical Activities; N = Administrative and Support Service Activities; O = Public Administration and Defence; Compulsory Social Security; P = Education; Q = Human Health and Social Work Activities; R = Arts, Entertainment and Recreation; S = Other Service Activities; T = Activities of Households as Employers; Undifferentiated Goods- and Services-Producing Activities of Households for Own Use; U = Activities of Extraterritorial Organisations and Bodies.

2.2 Expenditure approach

Table 4 presents all main components of *the expenditure approach* to GDP. As the most important changes between both standards relate to capitalisation, the most significant changes affected gross capital formation (GFC). The increase of GCF varies from 13% to 19% in the period between the years 1970 and 1990. After 1990 the development is similar. There are several explanations of this development. Prior to 1990 expenditures on R&D were relatively high. There were many research institutes with high number of workers. Contrariwise after 1990 the impact of small tools rose. This can be explained by purchases of small devices, software, laptops, mobile phones and other modern devices with a low purchasing value. The change of final consumption expenditures contains changes in government non-market output given by an increased consumption of fixed capital from selected new types of assets. A small change of household consumption represents an improvement in the measurement of dwelling services. The impact on export and import is given by processing services. As exports and imports are available only for former Czechoslovakia we originally used the available data – i.e. those based on MPS – for the Czech Republic and Slovakia.

Table 3 Changes in gross value added broken down by industries (CZ-NACE), mil. CSK/CZK, current prices

	1970			1980			1990			2000			2010		
	ESA 2010	ESA 1995	diff. (%)	ESA 2010	ESA 1995	diff. (%)	ESA 2010	ESA 1995	diff. (%)	ESA 2010	ESA 1995	diff. (%)	ESA 2010	ESA 1995	diff. (%)
A	25 884	25 619	1.0	32 904	32 440	1.4	48 745	48 336	0.8	74 111	74 301	-0.3	60 217	56 659	6.3
B+C+D+E	118 254	111 359	6.2	187 543	176 731	6.1	236 467	222 618	6.2	668 006	638 892	4.6	1 071 734	1 015 455	5.5
F	25 926	24 755	4.7	36 374	34 394	5.8	52 419	49 690	5.5	138 046	135 607	1.8	246 127	250 786	–1.9
G+H+I	45 680	44 117	3.5	81 625	79 072	3.2	114 987	111 208	3.4	470 150	470 385	0.0	668 181	663 610	0.7
J+K+L	16 433	17 445	–5.8	31 410	33 082	–5.1	49 962	52 334	–4.5	335 233	281 895	18.9	675 589	590 809	14.3
M+N	11 158	9 350	19.3	16 870	13 870	21.6	22 036	17 577	25.4	126 751	117 996	7.4	237 179	233 167	1.7
O to U	28 872	26 085	10.7	51 730	47 509	8.9	87 555	80 853	8.3	355 660	345 925	2.8	623 842	609 812	2.3
Total	272 207	258 730	5.2	438 456	417 098	5.1	612 172	582 616	5.1	2 167 957	2 065 001	5.0	3 582 869	3 420 298	4.8

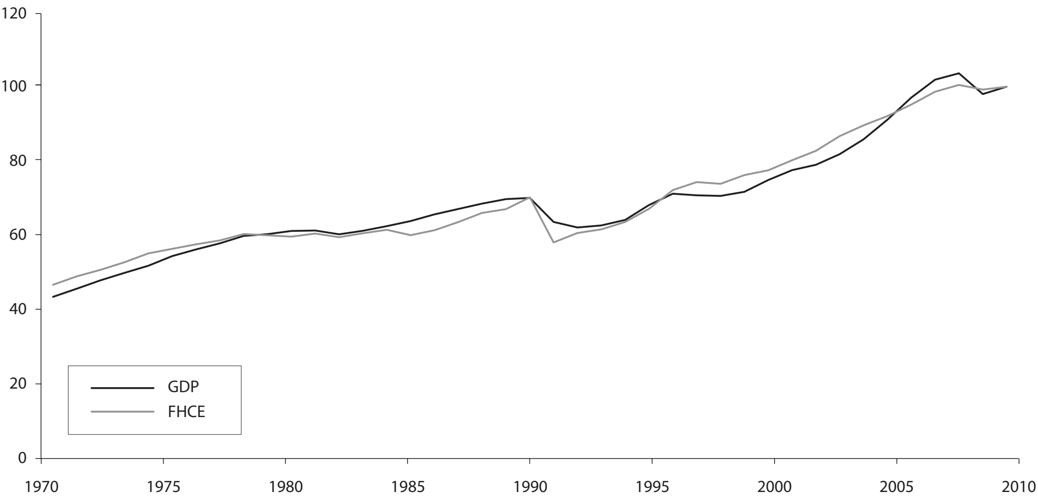
Source: Czech Statistical Office, authors' calculation (1970–1989)

Table 4 The components of expenditure approach to GDP, bn. CSK/CZK

		1970	1975	1980	1985	1990	1995	2000	2005	2010
ESA 1995	GDP	293.0	384.1	459.2	520.6	632.7	1 533.7	2 269.7	3 116.1	3 775.2
	FCE	194.7	253.3	305.7	364.4	464.9	1 096.4	1 639.0	2 205.1	2 707.6
	GCF	74.9	108.1	122.1	118.9	152.8	492.8	679.3	825.9	947.1
	NX	23.4	22.7	31.5	37.3	287.8	741.7	1 391.6	2 025.9	2 592.2
ESA 2010	GDP	306.4	401.8	480.6	546.3	672.8	1 580.1	2 372.6	3 258.0	3 953.7
	FCE	197.1	256.4	309.5	369.7	476.7	1 094.1	1 669.2	2 231.0	2 756.8
	GCF	86.0	122.7	139.6	139.4	181.1	535.1	747.4	950.3	1 074.4
	NX	23.4	22.7	31.5	37.3	274.4	644.0	1 152.7	2 046.8	2 645.5

Source: Czech Statistical Office, authors' calculation (1970–1989)
Note1: GDP = Gross domestic product, FCE = Final consumption expenditure, GCF = Gross capital formation, NX = Net exports of goods and services.
Note2: Imports and exports are not available separately. Only net export is known.

Figure 4 GDP and Final household consumption expenditures per capita, constant prices of 2010, 1970–2010



Source: Czech Statistical Office, authors' calculation (1970–1989)

GDP and all other macroeconomic indicators of national accounts were affected both at current and constant prices. All the adjustments had to be deflated separately with their individual price indices. Despite that the resulting impact on real aggregates is very limited because none of these adjustments fluctuate significantly in consecutive years. The impact on GDP varies from –0.2% to 0.2% in the period in question. As figure 4 shows, in 1970 the real GDP per capita was only 45.5% of its value in 2010. GDP per capita increased 2.3 times and final household consumption expenditures 2.1 times. Between the years 1970 and 1980 Czech economy was permanently growing. In early 1980s, former Czechoslovakia suffered from a deferred oil-shock as the Soviet Union increased their oil prices. On the other hand, late 1980s were connected with deep socio-economic changes. After 1996 we observed an increase of the economy which ended by the economic recession in 2009.

CONCLUSION

There is a demand and good use for long time series of macroeconomic indicators. Some important decisions, not only political, largely dependent on the data from national accounts. For example, regional funds extensively rely on the data published by regional accounts or the Treaty of Maastricht emphasized the role of government accounts deficit and debt etc. Moreover, a lot of research mainly from academic sphere require data for a long time analysis. Therefore, we prepared the historical time series of Czech GDP according to ESA 1995. These data were published in 2013. Unfortunately, the implementation of ESA 2010 in 2014 made our work out to date. Thus, we updated our previous research and recalculated the expenditure and production approaches to GDP in ESA 2010.

This paper presents our first results and differences between the results gained in ESA 1995 and ESA 2010. The implementation of ESA 2010 brought about a significant impact mainly on gross capital formation as most of the adjustments concerned capitalisation. Another important alteration emerged in the value of GDP and final household consumption expenditures per capita in constant prices of 2010. GDP per capita increased 2.3 times and final household consumption expenditures 2.1 times.

All figures prepared within this project are fully consistent with the data officially published by CZSO from 1990 onwards and will be published at the website of the Department of Economic Statistics at the end of 2016. Our results will present the figures of total employment divided by the NACE rev. 2 classification as well. This allows us to recalculate labour productivity of Czech industries as it was presented in Vltavská and Sixta (2015). Moreover, we will prepare the income approach which was not prepared in ESA 1995. This brings us a new look at the income side of the economy.

ACKNOWLEDGEMENT
This paper has been prepared under the support of the project of the University of Economics, Prague – Internal Grant Agency, project No. 17/2015 "GDP of the Czech Republic for the period between the years 1970 and 1989 based on ESA 2010".

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Job and Employee Stocks and Flows in the Czech Republic

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Abstract

The main aim of this paper is to present a comprehensive system of statistical information concerning the labour market with respect to the theoretical background as well as to the latest trends in the labour market statistics. This framework interlinks relations between demand and supply sides of the labour market as well as stocks and flows. In addition to the generally known indicators of economic activity, the authors define a new set of employment indicators derived from job creation, job destruction, hires and separations. There have never been quantified and balanced the demand and supply side stocks and flows in the Czech Republic, so the pilot results concerning the year 2010 are introduced as well. The systematic approach, based on a wider use of linked employer-employee microdata combined with other data sources, has the advantages of a higher information capability as well as of complying with the requirements of the academics.

Keywords	***JEL code***
System of labour market indicators, worker flows, job flows, Czech Republic	*C82, J21, J63*

INTRODUCTION

The research concerning fundamental relations and processes in the labour market is an important task for each country. A comprehensive system of labour market indicators enables to identify the point during the economic cycle that the economy is approaching, so the results support policy-makers in their strategic choices on the economic policy. A further reason for developing of relevant labour market indicators lies in the fact that the labour market equilibrium can be achieved through a low labour market turnover or through turbulences in the form of a high degree of staff turnover. Generally known indicators of economic (in)activity are usually focused on monitoring stocks, so they provide only a minimum information on structural changes in the labour market. Contrary to that, a comprehensive system of labour market indicators encompasses a range of aspects including labour market trends, demographic situation, etc. and can ensure (and in many countries it actually does) consistent and comparable data on stocks and flows in the labour market. Due to this fact, the systematic approach is generally recommended and represents current trend in an international context.

A crucial role in the quantification of labour market stocks and flows plays undoubtedly the work of Davis and Haltiwanger (1989, 1990, 1992, 1999) and Davis et al. (1996, 2006), who were followed by number of international research teams (Abowd et al., 1996; Albaek and Sørensen, 1998; Bruil et al.,

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2010; Centeno et al., 2009; Page, 2010). Nowadays, their approach represents mainstream in the research of labour market indicators, however, there has not been paid enough attention to link these indicators with the currently used ones so far. As a result, there exist two independent sets of indicators and it may appear, at first sight, that there is not a causal link between both systems (i.e. between currently used indicators of stocks and indicators of flows developed under the research projects).

Therefore, the main aim of this paper is to introduce the system of labour market indicators that eliminates imperfections of the above mentioned approach. The system will be designed in such a way to connect stocks and flows in the labour market and to ensure adequate links between supply and demand sides of the labour market. Moreover, the system will be based on fundamental findings of the economic theory concerning the labour market functioning in order to be utilizable also for a verification of theoretical labour market models without further limitations. However, when switching from an economic to statistical labour market perspective, it will be necessary to deal with so called adequation problem, i.e. it will be necessary to match economic terms with precisely defined statistical indicators (see Fischer and Sixta, 2009). Subsequently, the higher information value will be illustrated with a particular example of the Czech labour market.

The structure of the paper is as follows: section 1 introduces a theoretical framework of the labour market that will provide a basis for the system of labour market indicators proposed in section 2. Section 3 presents data sources and methods used. The main empirical results concerning the Czech labour market in 2010 are presented in section 4. The last section concludes the paper.

1 THEORETICAL MODEL

There is a great deal of theoretical work on the labour market, however, the use of principal findings and conclusions drawn from the economic theory is usually limited because of fundamental differencies between economic schools of thought – be it assumptions, conclusions or recommendations.[3] As for the labour market statistics, it is essential to focus on various states of the labour market that relate to labour market transitions as well as to the reallocation of jobs and workers. As far as the systematic approach to the labour market statistics is concerned, it is important to identify basic relations and transitions on the labour market. Doing so, one can encounter the above mentioned problem of the inconsistency of individual economic schools, but fortunately, all of the economic schools respect the law of supply and demand, and differ in fact in the explanation of the scope and nature of stimuli and motivations of individual agents on the labour market. Therefore, the labour market functioning can be described as follows.

In the labour market, as in other markets, there are production factors whose utilization adjusts to the economic cycle. As a factor of production, labour represents human resources involved in the production process and is the subject to the law of supply and demand. On the demand side of the labour market, there create employers new jobs or destruct redundant jobs. On the supply side of the labour market, there offer workers their labour and are ready to accept the job at least at individuals' reservation wage rate (def. by Lippman and McCall, 1976), i.e. the lowest wage rate demanded by an individual worker. When the employer offers less than the reservation wage, the worker leaves the job or does not even apply for a particular job (Burdett and Mortensen, 1998).

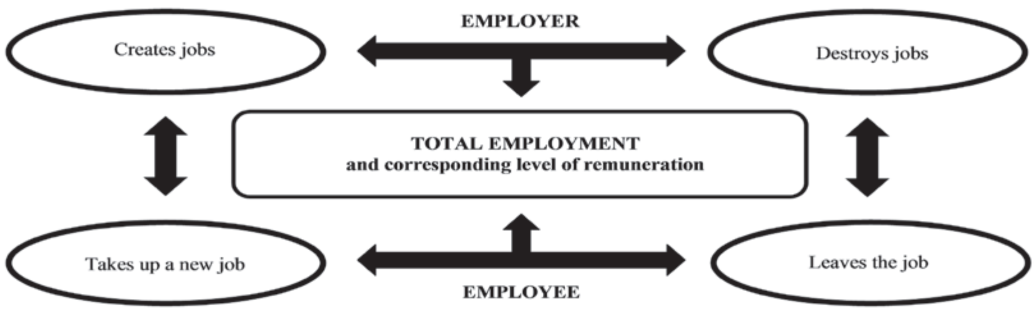
Just as each worker sets his or her lowest acceptable wage, employers usually set – with respect to the worker's contribution to the employer's revenue – their level of remuneration that they are willing to pay for a particular job. Thesedays almost nobody doubts, that employers can voluntarily keep a higher wage level compared to an equilibrium wage rate. As for the standard neoclassical model, its assumptions have already been overcome (see e.g. Cahuc and Zylberberg, 2004; Isard, 1977; Kaufman, 1999; Brown,

3 The theoretical research on the labour market is summarized e.g. by Blau et al. (2006), Boeri and van Ours (2008), Borjas (2010), Cahuc and Zylberberg (2004), Ehrenberg and Smith (2009), Manning (2003) or Saint-Paul (2000).

1985; Rutherford, 2001), and employers can keep wage rates at higher levels for rational reasons. In fact, employers can – thanks to higher wage rates – control the worker turnover (Lane et al., 1996a; Stiglitz, 1974; Schlicht, 1978), the probability of hiring less qualified employees (Malcomson, 1981; Weiss, 1980; Burdett and Mortensen, 1998; Manning, 1993) as well as staff morale (Calvo and Wellisz, 1979; Rebitzer and Taylor, 1995; Mankiw, 1998; Shapiro and Stiglitz, 1984).

As mentioned above, employers and employees meet on the labour market and respond to different impulses. Responses of individuals vary, but in total, they lead to the particular level of employment and remuneration. Figure 1 shows a theoretical framework of the labour market that is neutral with respect to all economic schools of thought. This framework interlinks relations between employers and employees and clearly shows not only the above mentioned relations between employees and employers, but also labour market transitions as well as job and worker reallocation (namely job creation, job destruction, hires and separations).

Figure 1 Basic relations and job and worker reallocation in the labour market

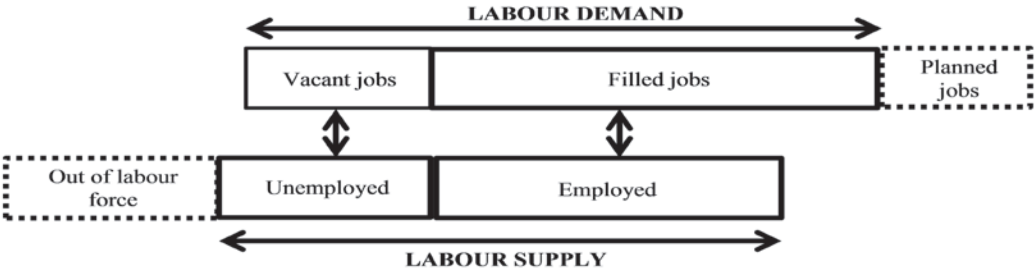


Source: Own construction

As an alternative, the above mentioned theoretical framework can be described in terms of categories of labour supply and demand. Figure 2 clearly depicts the relationship between supply and demand in the labour market. As shown in Figure 2, filled jobs on the demand side reflect the situation of employed persons on the supply side and represent successfully matched jobs and workers. However, essential information on the labour market is contained in the relation between unemployed persons and vacancies. The number of job seekers usually exceeds the number of unfilled jobs, so the so-called Beveridge relation is regarded as an important indicator of the labour market dynamics (see e.g. Blanchard and Diamond, 1989). As for the efficiency of the labour market in terms of matching jobs and workers, many empirical studies have confirmed the simultaneous coexistence of unemployment and vacancies, i.e. the reallocation on the supply and demand sides generates delays in matching of both jobs and workers. The (mis)match between jobs and workers can be formalized using a matching function, that plays a key role in the search and matching theory (see Diamond, 1982; Blanchard and Diamond, 1989, 1990; Mortensen, 1994; Burdett and Mortensen, 1998; Pissarides, 1985, 2000; Postel Vinay and Robin, 2002; Kiyotaki and Lagos, 2007).

For the sake of completeness, it should be pointed out that the vast literature devoted to this subject has used the diagram in Figure 3 (see e.g. Blanchard and Diamond, 1990; Burda and Wyplosz, 1994; Broersma et al., 2000; Davis et al., 1996, and others). In this diagram, there are shown transitions between individual categories of economic activity (namely employed and unemployed persons) and persons out of the labour market. For the purposes of this article, persons out of the labour market refer

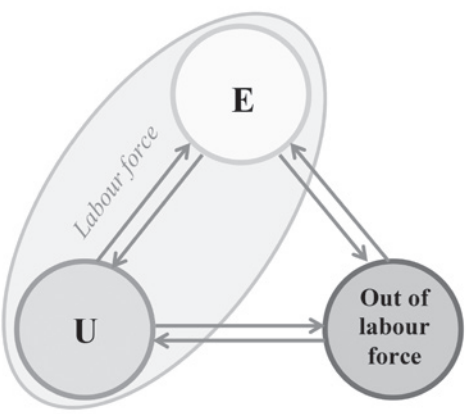
Figure 2 Relations between labour demand and supply



Source: Own construction based on Bruil et al. (2010) and Burda and Wyplosz (1994)

to economic inactive population as well as to all persons leaving the national labour market due to migration or death. It is obvious that Figure 3 displays only the transitions on the supply side of the labour market and omits several important aspects of the labour market covered by Figures 1 and 2. To be more specific, Figure 3 totally ignores the demand side of the labour market or the relationship between job and worker flows. Using such a labour market diagrams stems most likely from the fact that the literature on worker flows (i.e. on the labour supply) has developed separately from the literature on job flows (i.e. on the labour demand). In addition, most models have assumed job and worker flows to be equal (Burgess et al., 2000). Fortunatelly, empirical research on the relationship between the demand and supply sides of the labour market has brought the required turnaround because it has explained some of the labour market specifics as far as labour market functioning is concerned (e.g. Lane et al., 1996b, confirmed that also expanding economic subjects destroy jobs and contracting employers create jobs). This appears to be the reason why the synthesis of approaches has taken on greater significance and the number of comprehensive studies has continually increased (Burda and Wyplosz, 1994; Hamermesh et al., 1994; Lane et al., 1996a, 1996b; Davis et al., 1996, 2006; Burgess et al., 2000, etc.) instead of studying only the supply side (Pissarides, 1985, 2000; Blanchard and Diamond, 1989, 1990) or demand side (Dunne et al., 1989; Davis and Haltiwanger, 1990, 1992).

Figure 3 Basic relations and transitions on the supply side of the labour market



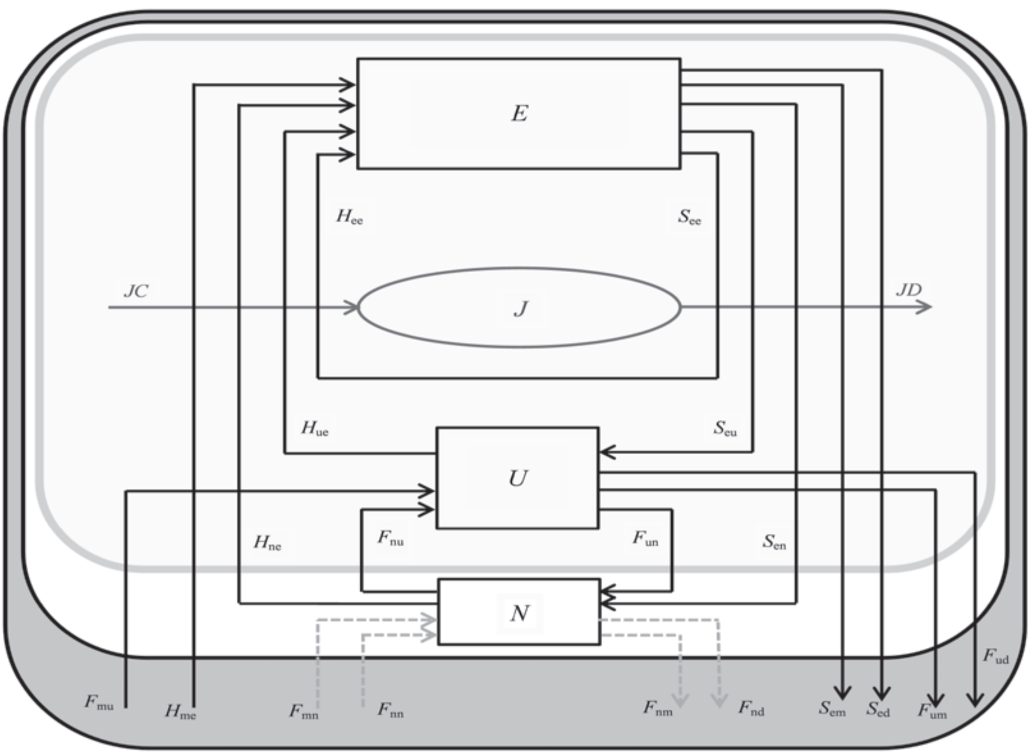
Note: *E* stands for employment, *U* unemployment.
Source: Own construction based on Blanchard and Diamond (1990), Burda and Wyplosz (1994) and Broersma et al. (2000)

2 SYSTEM OF LABOUR MARKET INDICATORS

The system of statistical information concerning the labour market in the Czech Republic, presented in this article, complies with both the theoretical background and latest trends in the labour market statistics. The most likely advantage of the new system is the fact that all the key aspects of the labour market are surveyed and evaluated together. In addition, the system interlinks relations among employees and employers. Figure 4 shows all stocks and flows included into the comprehensive national system of labour market at the macro level. This scheme is based on the national accounting system proposed by Bruil et al. (2010), but it was not effective to take over their system as a whole because they abstained from some events and flows (migration, deaths) for reasons of simplicity. The system proposed in this article extends their model and handles stocks and flows in the labour market in the wider context. Figure 4 shows mutual interactions between the supply and demand sides of the labour market (represented by the pale grey area), but also relations of individual players in the labour market to persons who are staying out of the labour market. In this article, we distinguish between different states of being out of (un)employment. In the national context, the stock of persons out of the labour market includes economically inactive population (such as students, pensioners, etc.) represented by the white area in Figure 4. In the dark grey area, there are allocated transitions that are not captured by the white area. To be more specific, the dark grey area covers transitions on account of migration (emigration, immigration) and the natural increase of population (live births, deaths). As stated by Pořízková (2008), migration plays a crucial role also in the Czech labour market, so it cannot be omitted from the system.

The system of labour market information includes four stocks. On the supply side of the labour market, there are three stocks classified, namely Employed (E), Unemployed (U) and economically inactive persons (N). On the demand side, there is the number of Jobs (J) classified.

Figure 4 System of labour market indicators in the Czech Republic



Source: Own construction

Above mentioned stocks are very closely related to flows that can be detected only in the labour market (i.e. transitions between employment and unemployment) or they refer to economically inactive persons or migrants. Figure 4 depicts transitions of employed persons that are denoted as *H* and *S* (where *H* refers to newly hired employees and *S* to separating employees), as well as transitions of unemployed and economically inactive persons denoted as *F*. Subscripts denote one by one initial and final labour market status, where

H_{xe} represents transitions from categories X (x = e, m, n, u) to category E (i.e. to the employment),

S_{ex} transitions from E (i.e. from the employment) to X (x = d, e, m, n, u),

F_{xy} transitions from X (x = m, n, u) to Y (y = m, n, u).

Initial and final categories of the labour market status are used in accordance with indicators mentioned above, or they imply events concerning other than current population of a given country, i.e. *M* is used for migration and *D* for deaths.

As for employment, we identified following labour market transitions:

H_{me} – immigrants who found a job and became employed,
H_{ue} – unemployed persons who found a job,
H_{ne} – persons out of the labour force who entered the employment,
H_{ee} – employed persons who switched the job,
S_{em} – employed persons who emigrated,
S_{eu} – employed persons who were laid off,
S_{en} – employed persons who left the labour force,
S_{ed} – employed persons who died and
S_{ee} – employed persons who left the job but moved to another job (without delay).

In Figure 4, there are depicted flows that influence labour market via unemployment. Namely, these flows are as follows:

F_{nu} – persons currently out of the labour force who entered the labour market and became unemployed,
F_{mu} – immigrants who became unemployed,
F_{un} – unemployed job searchers who left the labour force,
F_{um} – unemployed persons who emigrated, and
F_{ud} – unemployed persons who died during the given period.

For the sake of completeness, there are depicted flows in Figure 4 that are not directly linked to the labour market. These flows are as follows:

F_{mn} – immigrants who are out of the labour force,
F_{nn} – newly born,
F_{nm} – persons who were out of the labour force and emigrated, and
F_{nd} – persons who were out of the labour force and died during the given period.

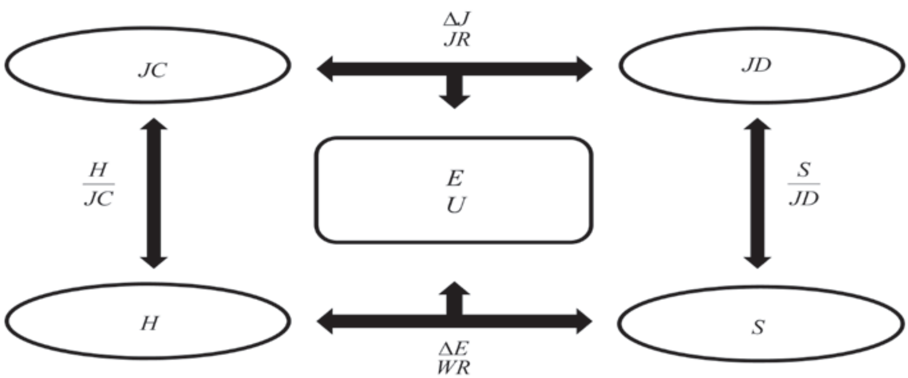
In addition to the labour status transitions, Figure 4 also depicts job-to-job flows (i.e. flows within the category of employed persons). As Bruil et al. (2010) point out, in adressing labour market flexibility, the focus should be on all movements of workers into and out of jobs. Thus, omitting job-to-job flows understates the true magnitude of worker reallocation (Hyatt and McEntarfer, 2012) and the measure would not count all labour market transitions. Neglecting job-to-job flows leads also to the biased conclucions concerning the labour market elasticity because there would not be any information on worker flows with no job creation and destruction (i.e. on workers who have left their jobs and moved to another jobs, and at the same time, the old jobs have remained and been filled by other workers).

As for the demand side of the labour market, there were two basic flows identified, namely creation (*JC*) and destruction of jobs (*JD*).

Furthermore, Figure 4 also shows situations when supply and demand sides of the labour market meet. These situations are depicted in those points where job flows intersects worker flows. To be more specific, Figure 4 depicts the inflow into employment from unemployment followed by job creation (point of intersection of lines *JC* and H_{ue}), destruction of jobs after the workers' deaths (*JD* and S_{ed}), etc.

Relations between labour market indicators are shown in Figure 5. In fact, this diagram is a statistical mirror to the theoretical framework of the labour market shown in Figure 1. Figure 5 depicts the above mentioned indicators (*JC*, *JD*, *H*, *S*, *E*, *U*) as well as other, derived indicators. On the demand side of the labour market, there are two indicators described, namely the net change of jobs (ΔJ, see below) and job reallocation (*JR*, see below). On the supply side of the labour market, there are two following indicators depicted – the net employment change ΔE, see below) and worker reallocation (*WR*, see below). Relations between supply and demand sides are measured using a ratio of the number of hires to job creation, or a ratio of the number of separations to job destruction. Using these ratios, it is possible to measure the labour market flexibility, i.e. to conclude, whether the Czech labour market is flexible or rather rigid in terms of fluctuation. In the case of the above mentioned ratios with an estimated value higher than 1, the staff turnover is several times higher than would be required by the demand side of the labour market. In other words, these values indicate the lack of the stability of workers that has significant negative consequences for staff loyalty, commitment and performance.

Figure 5 Stocks and flows on the demand and supply sides of the labour market and the links between them



Source: Own construction

Stock indicators, namely the number of employed, unemployed and economically inactive persons, are currently very well covered by the labour market statistics. These indicators are commonly known and quantified on the basis of internationally accepted recommendations, so we decided not to pay more attention to them.[4] Similarly, we will not further discuss the relation of vacancies and unemployed persons, because this issue has already been deeply analysed by Galuščák and Münich (2007). Instead, we will focus on indicators that are not commonly used in the Czech Republic. It should be noted that many of these indicators have not even been defined in the Czech Republic.[5]

[4] Description of methodology, indicators as well as links to corresponding international recommendations or European regulation for LFS is accessible in CZSO (2014b). On business statistics, which is a source for information on the average gross wage in the Czech Republic and average registered number of employees, focus Eurostat (2010) and CZSO (2014a). With labour costs, as an integral part of business statistics, deals Eurostat (2011). Methodology of ISPV describes MPSV (2013). Methodology of national accounts is described in CZSO (2012). Issues connected with registered unemployment follows up CZSO (2014b), evidence of vacancies then MPSV (2012).

[5] The basic indicators (*H*, *S*, *JC*, *JD*, ΔE, *JR*, *WR*) have already been used for other purposes by Duspivová (2011) and Duspivová and Spáčil (2011). These indicators are an integral part of the system of labour market indicators, and therefore will be defined also in this article.

More formally, labour market indicators are as follows:

Consider an economic subject *s* holding a job *j* with an employee *e* in the subset of economic subjects *o* (industry, region, etc.) in the time period *t*. The *number of employees* (*E*) of the subject *s* in the time period *t* is defined as follows (1)

$$E_{so}^{(t)} = \sum_{i=1}^{n} e_{so}^{(t)}, \tag{1}$$

the *net employment change* in the economic subject *s* is defined as (2)

$$\Delta E_{so}^{(t)} = E_{so}^{(t)} - E_{so}^{(t-1)}. \tag{2}$$

Total number of jobs (*J*) in the economic subject *s* is defined as (3)

$$J_{so}^{(t)} = \sum_{i=1}^{n} j_{so}^{(t)}, \tag{3}$$

and the *net change of jobs* (Δ*J*) in the economic subject *s* is defined as (4)

$$\Delta J_{so}^{(t)} = J_{so}^{(t)} - J_{so}^{(t-1)}. \tag{4}$$

Basic indicators of job and employee flows are defined as follows:
hires (*H*) in all of the economic subjects in the subset *o* according to Davis et al. (1996) as

$$H_{so}^{(t)} = \sum_{i=1}^{n} e_{so_i}^{(t)}, \text{ where } (e_{so_i} \in s^{(t)}) \wedge (e_{so_i} \notin s^{(t-1)}), \tag{5}$$

separations (*S*) from all of the economic subjects in the subset *o* according to Davis et al. (1996) as

$$S_{so}^{(t)} = \sum_{i=1}^{n} e_{so_i}^{(t)}, \text{ where } (e_{so_i} \in s^{(t-1)}) \wedge (e_{so_i} \notin s^{(t)}), \tag{6}$$

job creation (*JC*) in the subset of economic subjects as (7)

$$JC_{so}^{(t)} = \sum_{k=1}^{m} j_{so_k}^{(t)}, \text{ where } (j_{so_k} \in s^{(t)}) \wedge (j_{so_k} \notin s^{(t-1)}), \tag{7}$$

job destruction (*JD*) in the subset as (8)

$$JD_{so}^{(t)} = \sum_{k=1}^{m} j_{so_k}^{(t)}, \text{ where } (j_{so_k} \in s^{(t-1)}) \wedge (j_{so_k} \notin s^{(t)}). \tag{8}$$

As for hires, there can be applied the identity based on Figure 4 (9)

$$H^{(t)} = H_{\mathrm{ee}}^{(t)} + H_{\mathrm{ue}}^{(t)} + H_{\mathrm{ne}}^{(t)} + H_{\mathrm{me}}^{(t)} \tag{9}$$

as well as for separations (10)

$$S^{(t)} = S_{\mathrm{ee}}^{(t)} + S_{\mathrm{eu}}^{(t)} + S_{\mathrm{en}}^{(t)} + S_{\mathrm{em}}^{(t)} + S_{\mathrm{ed}}^{(t)}. \tag{10}$$

Total number of jobs can be calculated using the following formula (11)

$$J = J_M + J_V, \tag{11}$$

where J_M identifies filled jobs and J_V vacant jobs.

In addition to the basic indicators defined above, there can be other comprehensive indicators derived, namely *total employment change* (ΔE_{sot}) is defined as (12)

$$\Delta E_{so}^{(t)} = JC_{so}^{(t)} - JD_{so}^{(t)} = H_{so}^{(t)} - S_{so}^{(t)}, \tag{12}$$

worker reallocation (*WR*) according to Davis et al. (1996) as (13)

$$WR_{so}^{(t)} = H_{so}^{(t)} + S_{so}^{(t)} \tag{13}$$

and *job reallocation* (*JR*) defined by Davis et al. (1996) as (14)

$$JR_{so}^{(t)} = JC_{so}^{(t)} + JD_{so}^{(t)}. \tag{14}$$

Relationship between individual indicators can be expressed using ratios mentioned in relation to Figure 5, i.e.

$$R^{+} = \frac{H}{JC} \tag{15}$$

$$R^{-} = \frac{S}{JD}. \tag{16}$$

Furthermore, it is possible to quantify indicators that assess labour market dynamics from a different perspective. For example, *excess job reallocation* (*EJR*) defined according to Davis et al. (1996) as (17)

$$EJR_{so}^{(t)} = JR_{so}^{(t)} - \left|\Delta E_{so}^{(t)}\right| = JC_{so}^{(t)} + JD_{so}^{(t)} - \left|JC_{so}^{(t)} - JD_{so}^{(t)}\right| \tag{17}$$

provides a measure of the job reallocation beyond the minimum change in employment. In other words, this indicator says about job changes that are not necessary to accomodate the net employment change and, put simply, occurred unnecessarily. As another example may serve an indicator defined according to Bassanini and Marianna (2009) in the form of *excess worker reallocation* (*EWR*) (18)

$$EWR_{so}^{(t)} = WR_{so}^{(t)} - \left|\Delta E_{so}^{(t)}\right| = H_{so}^{(t)} + S_{so}^{(t)} - \left|H_{so}^{(t)} - S_{so}^{(t)}\right|, \tag{18}$$

that measures worker flows, that occurred beyond the minimum necessary to achieve the net employment change.

Then we can define an indicator of worker flows in excess of job flows, that is usually called *churning* (*CH*). This indicator provides a measure of worker flows not related to job flows, and can therefore approximate the worker flows in stable jobs. Churning can be defined in accordance with Burgess et al. (2000) as

$$CH_{so}^{(t)} = WR_{so}^{(t)} - JR_{so}^{(t)}, \tag{19}$$

or according to OECD (2009) as

$$CH_{so}^{(t)} = EWR_{so}^{(t)} - EJR_{so}^{(t)}, \tag{20}$$

where the following identity holds according to Haltiwanger et al. (2012)

$$H_{so}^{(t)} - JC_{so}^{(t)} = S_{so}^{(t)} - JD_{so}^{(t)} . \tag{21}$$

According to Tornquist et al. (1985), to convert time-t measures to rates, we divide the corresponding figure by the average of employment at t and $t-1$, i.e.

$$\overline{E}_{so}^{(t)} = \frac{E_{so}^{(t)} + E_{so}^{(t-1)}}{2} , \tag{22}$$

hence individual rates are as follows (using lower case letters for the rates):

$$jc_{so}^{(t)} = \frac{JC_{so}^{(t)}}{\overline{E}_{so}^{(t)}} , \tag{23}$$

$$jd_{so}^{(t)} = \frac{JD_{so}^{(t)}}{\overline{E}_{so}^{(t)}} , \tag{24}$$

etc.

3 DATA AND METHODOLOGY

The system of labour market indicators, proposed in the previous chapter, will be more data demanding in comparison to the generally known basic set of labour market indicators. In order to be able to make meaningful conclusions on the labour market dynamics, the indicators of the supply side should be consistent with indicators of the demand side (Davis et al., 1996). Consistent measurement of individual processes in the labour market requires ideally an integrated data source that links the both populations of workers and employers (Burgess et al., 2000). As for the Czech Republic, development of such an integrated data source, that will incorporate data about persons as well as economic entitities, is limited because of the complicated legal situation from the perspectives of data treatment and their potential linkage. This is the reason, why individual indicators depicted in Figure 4 will be estimated using the combination of the following data and data sources:

- the labour force survey (LFS) (in particular CZSO, 2010, 2011d, 2011e);
- transition probabilities according to CZSO (2011b);
- stocks and flows of population (CZSO, 2011a, 2011c, 2014c);
- job and worker flows in the wage sphere (Duspivová and Spáčil, 2011);
- vacancies according to the Ministry of Labour and Social Affairs (MPSV) statistics;
- statistics of job applicants from EU and the European Economic Area managed by the MPSV;
- foreigners employment statistics managed by the MPSV and
- data on valid trade licences granted to foreigners by the Ministry of Industry and Trade of the Czech Republic (MPO).

Because of lack of relevant microdata, we will exploit the internal consistency of data on stocks and flows at the macro level. Doing so, we will use the most suitable available data for each indicator.

All the figures presented in the next part are the annual measures and the reference year is 2010. This period was chosen intentionally because for another period, there is no information available on labour market transitions based on the LFS and grossed up to the universe (CZSO, 2011b).

The measurement unit of indicators of the supply side of the labour market is a physical person (i.e. each person is alloted to one stock only). In order to be able to compare supply and demand sides of the labour market, it is necessary to precisely define a job. Usually, a job is defined as an agreement between an employee and an employer (Burda and Wyplosz, 1994; Davis et al., 1996; Pissarides, 2000; methodology of national accounts SNA 2008 according to UN, 2009). Using such a definition of the job would provide the biased information on the Czech labour market because the LFS category of employed persons contains apart employees (i.e. those persons who are directly linked to the jobs in terms of the above mentioned definition) also self-employed persons and employers. In accordance with Bruil et al. (2010), the definition of the job will be broadened to job vacancies as well. Job vacancies are an important part of the labour demand, because of the information on vacancies we can, among others, evaluate achieving of the labour market equilibrium. So, the total number of jobs at the macro level will be defined as the sum of:

- jobs created by employers (see the usual concept of the job),
- jobs created by self-employed and employers for themselves (on the basis of a notional, fictitious agreement) and
- job vacancies.

The following is the description of our construction methods.

3.1 Labour supply

Stocks

Stocks on the supply side of the labour market at the beginning and end of the period were set as follows:

- $E^{1.1.2010}$, $U^{1.1.2010}$, $N^{1.1.2010}$ were set according to the LFS results in the 1st quarter of 2010 (CZSO, 2010). As for the population aged 15 and older (population 15+), the difference between the number of population on 1 January 2010 according to the demographic statistics (CZSO, 2011a) and the LFS amounts to 0.01% of persons. We consider this difference as negligible for the above mentioned purposes;
- $E^{31.12.2010}$, $U^{31.12.2010}$, $N^{31.12.2010}$ were set according to the LFS results in the 4th quarter of 2010 (CZSO, 2011e). As for the population 15+, the difference between the number of population on 31st December 2010 according to the demographic statistics (CZSO, 2011a) and the LFS amounts to 0.05% of persons. In this case, we also consider this difference as negligible.

Flows according to the labour market status

Worker flows according to the labour market status were derived from both transition probabilities published by CZSO (2011b) and an assumption that flows between the 3rd quarter of 2009 and 3rd quarter of 2010 are comparable to those between the 4th quarter of 2009 and 4th quarter of 2010. In fact, we assumed that transition probabilities in the 4th quarter of 2009 equaled to probabilities in the 4th quarter of 2010. Transition probabilities in 2010 were obtained by multiplying of all transition matrices in individual quarters (see Table 1). The flows between individual labour market statuses were estimated as follows:

- H_{ue}^{2010} was estimated as the transition probability Unemployed → Employed multiplied by $U^{1.1.2010}$;
- H_{ne}^{2010} as transition probability Economically inactive → Employed multiplied by $N^{1.1.2010}$;
- S_{eu}^{2010} as transition probability Employed → Unemployed multiplied by $E^{1.1.2010}$;
- S_{en}^{2010} as transition probability Employed → Economically inactive multiplied by $E^{1.1.2010}$;
- F_{nu}^{2010} as transition probability Economically inactive → Unemployed multiplied by $N^{1.1.2010}$;
- F_{un}^{2010} as transition probability Unemployed → Economically inactive multiplied by $U^{1.1.2010}$.

Table 1 Transition probabilities by the labour market status between the 3rd quarter 2009 and the 3rd quarter 2010

Q3 2009/ Q3 2010	Employed	Unemployed	Ec. Inactive
Employed	0.925	0.025	0.050
Unemployed	0.478	0.342	0.180
Ec. inactive	0.056	0.022	0.922

Source: Own calculation based on CZSO (2011b)

Migration

Flows connected with migration were estimated using data on cross-border migration according to age and sex (CZSO, 2011c) with an assumption that distribution of emigrants and immigrants according to the labour market status is identical with those of the Czech population. Individual flows were estimated as follows:

- S_{em}^{2010} was estimated as a number of emigrants multiplied by the specific employment rate according to age and sex in 2010;
- H_{me}^{2010} as a number of immigrants multiplied by the specific employment rate according to age and sex in 2010;
- F_{um}^{2010} as a number of emigrants multiplied by the share of unemployed persons according to age and sex in 2010. To check the robustness in terms of accuracy of our accounting system and to prevent underestimation on the basis of the demographic statistics, we compare this estimate with the number of job applicants moving abroad, that were registered by the MPSV;
- F_{mu}^{2010} as a number of immigrants multiplied by the share of unemployed persons according to age and sex in 2010. In this case, we compared our estimate based on the demographic statistics with the number of newly immigrated job applicants registered by the MPSV during all quarters of 2010;
- F_{nm}^{2010} as a number of emigrants multiplied by the share of economically inactive persons according to age and sex in 2010;
- F_{mn}^{2010} as a number of immigrants multiplied by the share of economically inactive persons according to age and sex in 2010.

Specific rates and shares according to age and sex were computed on the basis of the LFS results (CZSO, 2011d).

Demographic change

The numbers of employed, unemployed and economically inactive persons, who died during the period, were estimated according to the data concerning both the natural increase of population (CZSO, 2014c) and the LFS. We had to make an assumption that the distribution of dead persons according to the labour market status is identical with those of the Czech population. S_{ed}^{2010} was estimated as a sum of the number of dead persons in 2010 according to sex and age groups multiplied by the specific employment rate according to age and sex in 2010. The latter one was based on the LFS results (CZSO, 2011d). F_{ud}^{2010} was estimated as a sum of the number of dead persons in 2010 according to sex and age groups multiplied by the share of unemployed persons in the Czech population in corresponding sex and age groups. F_{nd}^{2010} was estimated as a sum of the number of dead persons in 2010 according to sex and age groups multiplied by the share of economically inactive persons in the Czech population in corresponding sex and age groups.

F_{nn}^{2010} was estimated as the number of live births in 2010 (see CZSO, 2011c).

Job-to-job flows

Stocks and flows of employees were estimated using the percentage share of employees in the category of employed persons. This share was 82% in 2010 (CZSO, 2011d).

Besides the flows quantified in the wage sphere (Duspivová and Spáčil, 2011), it was necessary to estimate the flows of employees who changed their jobs and remained employed.

The estimate of H_{ee}^{2010} proceeds from the total number of hires H^{2010}. H^{2010} was estimated as a sum of hires in the wage sphere and the minimum number of hires in the salary sphere. As for the latter, it equals to the number of jobs created in the salary sphere in 2010. Then, the individual flows concerning hires (based on the above mentioned percentage share of 82%) were subtracted from the total number of hires, i.e.

$$H_{ee}^{2010} = H^{2010} - H_{me}^{2010} - H_{ne}^{2010} - H_{ue}^{2010}. \tag{30}$$

The estimate of S_{ee}^{2010} proceeds from the total number of separations S^{2010}. S^{2010} was estimated as a sum of separations in the wage sphere and the minimum number of separations in the salary sphere. As for the latter, it equals to the number of jobs destroyed in the salary sphere in 2010. Then, the individual flows concerning separations (based on the above mentioned percentage share of 82%) were subtracted from the total number of separations, i.e.

$$S_{ee}^{2010} = S^{2010} - S_{eu}^{2010} - S_{en}^{2010} - S_{em}^{2010} - S_{ed}^{2010}. \tag{31}$$

Furthermore, the following identity was used

$$H_{ee}^{2010} = S_{ee}^{2010}, \tag{32}$$

because an employee, who left one economic entity (and therefore is covered by S_{ee}^{2010}), passed into another economic entity (and therefore is covered by H_{ee}^{2010}). The system was therefore necessary to balance in such a way to keep the identity (32). This identity was achieved by increasing S_{ee}^{2010} by 136 thousand persons. This balancing adjustment was carried out by separations because of the lower quality of the primary data source available for the salary sphere.

The above mentioned job-to-job flows of employees were further increased by the sum of persons changing their economic status from an employee to self-employed, and vice versa. The number of these transitions was estimated as the number of persons in individual category at the beginning of the period (CZSO, 2010) multiplied by the corresponding transition probability according to Table 2. The transition probabilities in Table 2 were calculated using the same methodology as well as assumptions as in the case of probabilities in Table 1. So, the job-to-job flows were increased by the number of employees who switched to self-employed persons (25 thousand persons) and by the number of self-employed persons who became employees (21 thousand persons) in 2010. Since both flows relate to the transitions within the category of employed persons, they were added to hires and separations in the same amount, and therefore no other balancing adjustments were needed.

Table 2 Transition probabilities by the economic status between the 3rd quarter 2009 and 3rd quarter 2010

Q3 2009/ Q3 2010	Employee	Self-employed	Without work
Employee	0.906	0.006	0.088
Self-employed	0.025	0.923	0.052
Without work	0.094	0.013	0.893

Source: Own calculation based on CZSO (2011b)

Balancing

Finally, there were worker and job flows balanced with respect to the stock information concerning the labour market in the Czech Republic. As for our accounting framework, three stock-flow equations were used, namely:

$$\begin{aligned} E^{31.12.2010} &= \\ &= E^{1.1.2010} + H_{me}^{2010} + H_{ne}^{2010} + H_{ue}^{2010} + H_{ee}^{2010} - S_{ee}^{2010} - S_{eu}^{2010} - S_{en}^{2010} - S_{em}^{2010} - S_{ed}^{2010}, \end{aligned} \tag{33}$$

$$U^{31.12.2010} = U^{1.1.2010} + S_{eu}^{2010} + F_{nu}^{2010} + F_{mu}^{2010} - H_{ue}^{2010} - F_{un}^{2010} - F_{um}^{2010} - F_{ud}^{2010}, \tag{34}$$

$$N^{31.12.2010} = N^{1.1.2010} + S_{en}^{2010} + F_{un}^{2010} + F_{mn}^{2010} + F_{nn}^{2010} - H_{ne}^{2010} - F_{nu}^{2010} - F_{nm}^{2010} - F_{nd}^{2010}. \tag{35}$$

During the balancing, we used additional data on the total number of the Czech population on 1st January 2010 and 31st December 2010. In an ideal case, the change in a stock should equal inflows minus outflows. As for the Czech population, this simple accounting rule does not hold because of the problems concerning recording of the cross-border migration in the demographic statistics.[6] Balancing adjustments of the stocks of employed, unemployed and economically inactive persons were carried out because the initial stocks were based on the LFS results (i.e. they referred to individual quarters, not to specific dates, e.g. to 1st January 2010 or 31st December 2010). Balancing adjustments are provided in Table 3.

Table 3 Balancing adjustments of the labour market indicators in the Czech Republic in 2010

Indicator	Result [thousand persons]	of which **balancing adjustment** [thousand persons]
$U^{1.1.2010}$	431	8
$U^{31.12.2010}$	355	–8
$N^{1.1.2010}$	5 228	–27
$N^{31.12.2010}$	5 286	31
H_{me}^{2010}	72	57

Source: Own calculation

3.2 Labour demand

Job stocks

$J^{1.1.2010}$ was estimated as the sum of employees, employees with a second job, employers, own-account workers, family workers and members of producers' cooperatives (all in physical numbers of persons) according to the LFS (CZSO, 2010) and vacancies in the 1st quarter of 2010. $J^{31.12.2010}$ was estimated as a sum of employed persons and employees with a second job according to the LFS (CZSO, 2011e) and vacancies in the 4th quarter of 2010. Job stocks were further adjusted using data on job flows (see below) to hold the equation

$$J^{31.12.2010} = J^{1.1.2010} + JC^{2010} - JD^{2010}. \tag{36}$$

Balancing adjustments were carried out to initial job stocks (+18 thousand jobs) as well as final job stocks (+17 thousand jobs).

Job flows

Estimates of JC^{2010} a JD^{2010} came out from an assumption that in the salary sphere, there is the lower level of flows compared to the wage sphere. Nowadays, no survey is available in any country similar to the Czech Republic that would focus on differences in the level of job and worker flows in the wage and salary spheres. Generally, the salary sphere is considered to be more stable part of an economy and is characterized by both the lower level of job flows and the higher stability of employees. That

6 The demographic statistics defines external migration as a change of a permanent stay of the person from the Czech Republic to abroad or from abroad to the Czech Republic (CZSO, 2001). Therefore, migration is not recorded if any change in permanent stay does not occur.

is confirmed e.g. by Pisani-Ferry (2003) who stated that the public sector participated in job creation in the French economy by only 15% during the period 1996–2001. We suppose, with regard to Pisani-Ferry (2003), that the wage sphere participated in job reallocation by 90% and salary sphere by 10%. Taking into consideration, that employment in the salary sphere was in 2010 more or less stable,[7] the job reallocation in the salary sphere is divided into created and destroyed jobs in the ratio of 1:1 (see Table 4).

Table 4 Estimates of job flows in the Czech Republic in 2010

Indicator	Result [thousand jobs]	share on reallocation [%]
JC_{WS}^{2010}	394	–
JD_{WS}^{2010}	184	–
JR_{WS}^{2010}	578	90
JR_{SS}^{2010}	64	10
JC_{SS}^{2010}	32	–
JD_{SS}^{2010}	32	–

Note: WS means the wage sphere, SS the salary sphere.
Source: Own calculation

In accordance with the definition of the job, there were estimated job flows that were connected with transitions of persons among economic statuses (above all with self-employed persons). Jobs were created in two cases – if an employee became self-employed (25 thousand jobs) or if a person out of the labour force became self-employed (56 thousand jobs). Jobs were destroyed in cases when a self-employed became an employee (21 thousand jobs) or left the labour market (43 thousand jobs). The estimates were based on the numbers of persons in individual categories according to CZSO (2010) and transition probabilities in Table 2.

Job flows were further adjusted in order to hold the equation (17). Since the difference between hires and separations amounted to 90 thousand persons, it was necessary to carry out the balancing adjustment concerning job flows in the amount of 136 thousand jobs. Due to this fact, the number of destroyed jobs was increased by 136 thousands.

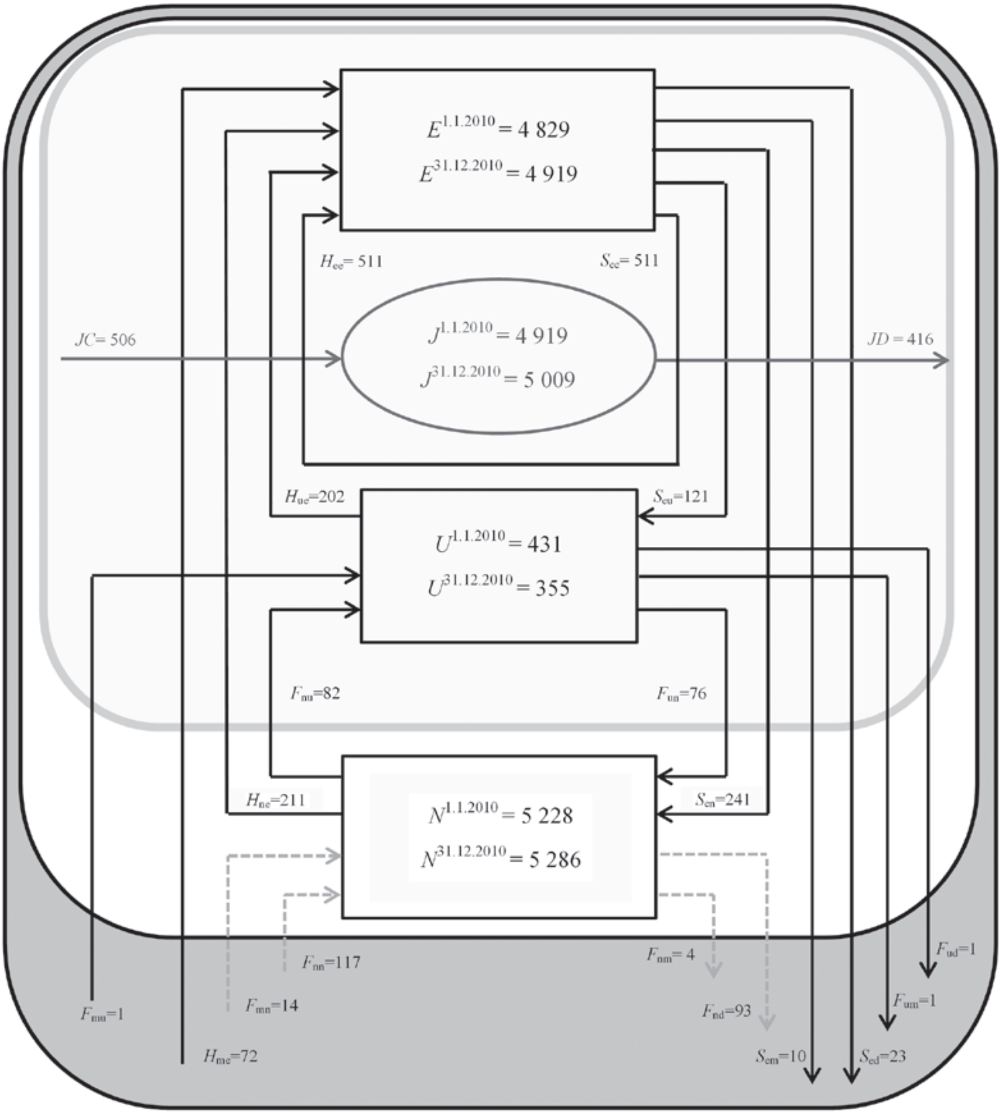
4 STOCKS AND FLOWS IN THE CZECH LABOUR MARKET

Figure 6 summarizes job and worker flows in the Czech labour market in 2010 as constructed by the system proposed in the previous chapters. Stocks and flows are balanced at the macro level and the units of measure are thousand jobs and thousand persons (i.e. each person is alloted to one stock only). Table 5 presents job and worker flows expressed as rates using denominator (22).

Figure 6 (and analogously Table 5) offers a new perspective on the Czech labour market dynamics. First, job flows involved 18.9% of jobs (jr^{2010}) and worker flows 39.0% of employed persons (wr^{2010}) in the Czech labour market in 2010. Second, the flows between labour market statuses appear to be particularly large. In 2010, 51.4% of unemployed persons found a job (i.e. the flow from unemployment to employment was related to 51.4% of unemployed persons), and otherwise put, 4.1% of employed persons represent the inflow from unemployment to employment. On the contrary, 2.5% of employed persons became unemployed and these persons accounted for 30.8% of the unemployed. From the Czech labour market perspective, there is also the migration important because 1.5% of workers immigrated in 2010.

7 According to CZSO (2011b), the average registered number of employees in the 1st quarter of 2010 in the salary sphere amounted to 742.7 thousand persons and 747.3 thousand persons in the 4th quarter of 2010.

Figure 6 Stocks and flows in the Czech labour market in 2010 (thousand persons, thousand jobs)



Source: Own calculation

Furthermore, Table 6 shows some keynote indicators of labour market dynamics that are of crucial importance for the social policy. To be more specific, the transitions between unemployment and economic inactivity may indicate, for example, that unemployed persons opt out from searching for a job. In 2010, 19.3% of the unemployed left the labour force, and vice versa, 20.9% of economically inactive persons became unemployed. Table 6 expands the analysis and shows the most important rates calculated with the denominator (22), i.e. the average number of employed persons ($\overline{E}^{2010}$), as well as with the denominators defined as the average number of unemployed ($\overline{U}^{\,2010}$) and economically inactive persons ($\overline{N}^{\,2010}$) in *t* and *t*–1.

Table 5 Job and worker flows rates in the Czech Republic in 2010

Indicator	[%]	Indicator	[%]	Indicator	[%]
h_{ue}^{2010}	4.1	s_{em}^{2010}	0.2	wr^{2010}	39.0
s_{eu}^{2010}	2.5	s_{ed}^{2010}	0.5	jr^{2010}	18.9
h_{ne}^{2010}	4.3	h^{2010}	20.4	ewr^{2010}	37.2
s_{en}^{2010}	4.9	s^{2010}	18.6	ejr^{2010}	17.1
h_{ee}^{2010}	10.5	jc^{2010}	10.4	ch^{2010}	20.1
s_{ee}^{2010}	10.5	jd^{2010}	8.5	R^{+}	2.0
h_{me}^{2010}	1.5	Δe^{2010}	1.8	R^{-}	2.2

Note: Differences in sums are caused by rounding.
Source: Own calculation

Table 6 Comparison of job and worker flow rates in the Czech Republic in 2010 according to different denominators

Rate [%]	Denominator		
	$\overline{E}^{2010}$	$\overline{U}^{2010}$	$\overline{N}^{2010}$
h_{ue}^{2010}	4.1	51.4	–
s_{eu}^{2010}	2.5	30.8	–
h_{ne}^{2010}	4.3	–	4.0
s_{en}^{2010}	4.9	–	4.6
f_{un}^{2010}	–	19.3	1.4
f_{nu}^{2010}	–	20.9	1.6
h_{me}^{2010}	1.5	–	–
s_{em}^{2010}	0.2	–	–

Source: Own calculation

Figure 6 shows also the flows within the category of employed persons (i.e. the job-to-job flows) that experienced 10.5% of workers. In 2010, the job-to-job flows accounted for 465 thousand workers who left their job and found another. A detailed analysis revealed that 21 thousand self-employed persons became employed and vice versa, 25 thousand employed persons became self-employed.

Due to the natural increase of population (live births, deaths) the number of employed persons decreased by 0.5%.

In Figure 6, we provide stocks and flows concerning jobs as well. As for stocks, the number of jobs exceeds the number of employed persons because a person may work in several jobs. In 2010, there were 10.4% of jobs created and 8.5% of jobs destroyed, so the net change in the number of jobs equals 1.8% (see Table 5). In fact, job flows may be even higher because any flows within firms have not been taken into account in this study. According to Hamermesh et al. (1994), accounting for simultaneous creation and destruction of jobs may increase economywide job flows by up to 15%. The same applies for worker flows as well.

Table 5 demonstrates several interesting facts about job and worker flows and their relations. The ratios defined in (15) and (16) indicate that the number of hires was two times higher than the number of jobs created in 2010, and the number of separations was more than two times higher than the number of jobs destroyed, respectively. The worker flows were much larger – by a factor of 2 – than the job flows. The pattern of excess turnover can be further detailed using both excess job reallocation (ejr^{2010}) and excess worker reallocation (ewr^{2010}). The evidence in Table 5 shows that worker flows exceeded the job flows in 2010, i.e. there was a vast amount of labour reallocation in the Czech labour market. About 17.1% of the jobs changes took place but these changes were not needed by firms to reach the desired employment level. As for worker flows, 37.2% of workers moved beyond required adjustment in the employment level. This is a clear evidence of significant levels of churning (ch^{2010}) in the Czech labour market in 2010, because 20.1% of the worker flows arose from permanent jobs. Otherwise put, 20.1 % of worker flows were not associated neither with creation nor destruction of jobs. This result is consistent with the measures of job-to-job flows (i.e. flows within the category of employed persons), namely h_{ee}^{2010} and s_{ee}^{2010}. The sum of both measures of job-to-job flows (10.5 and 10.5% respectively) corresponds with the level of churning.

CONCLUSION

The main aim of this paper was to present a new system of statistical indicators concerning the labour market in the Czech Republic with respect to the theoretical background as well as to latest trends in the labour market statistics.

First, a theoretical framework of the labour market was introduced. This framework interlinks relations between employees and employers, characterizes the processes associated with demand and supply sides of the labour market, and what is more, it is neutral with respect to all the economic schools of thought.

Then, there was the new system of statistical information concerning the labour market proposed. The most likely advantage of the new system is the fact that the system interlinks relations between employees and employers and all the key aspects of the labour market are evaluated together. The system proposed in this article extends current models and handles stocks and flows in the labour market in the wider context. Moreover, it provides new evidence on labour turnover caused by the natural increase of population as well as by migration. In addition to the generally known indicators of economic activity, we proposed new indicators of job creation, job destruction, hires, separations, job reallocation and worker reallocation. Furthermore, we defined aggregate indicators that allow us to assess labour market dynamics from a different perspective, namely excess worker reallocation, excess job reallocation and churning.

There have never been quantified the indicators concerning job and employee stocks and flows using integrated data source in the Czech Republic, so the pilot results were introduced in this paper. The worker and job flows were balanced with respect to the stock information concerning the labour market, so the measures of job and worker flows shed better light on employment dynamics. Conclusions that can be drawn from the proposed system have an essential importance also for the economic policy – actually, in 2010 the changes in the labour market were associated with 18.9% of jobs and 39.0% of workers in the Czech Republic.

The system brings a new insight to the dynamics of the labour market compared to the generally known basic set of labour market indicators. It is obvious that implementing the new system, we could prove some hypotheses that were impossible to prove before. The systematic approach, based on a wider use of linked employer-employee microdata combined with new indicators, has the advantages of a higher information capability as well as of complying with the requirements of the academics. Provided that sufficient data are available, it is possible to construct a consistent set of all relevant indicators at the macro level in a full time series.

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Analysis of Structural Differences and Asymmetry of Shocks Between the Czech Economy and the Euro Area[1]

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Abstract

The goal of this paper is to examine asymmetry of shocks and structural differences between the Czech economy and the euro area. For this purpose I use a New Keynesian DSGE model of two economies. Structural differences are examined using the posterior distributions of structural parameters. Results suggest that prices are more sticky in the Czech economy, especially in the non-tradable sector, while wages are more sticky in the euro area. It seems that the ECB smooths less the interest rate and reacts more to the development in output and inflation than the Czech National Bank. It also seems that labor supply in the Czech economy is more elastic than labor supply in the euro area. Asymmetry of shocks is examined using correlations between smoothed shocks obtained from the estimation. The most asymmetric shocks are shocks in government expenditures, labor supply shocks, and productivity shocks in the tradable sector, while the most symmetric shocks are consumption preference shocks, monetary policy shocks, and investment efficiency shocks.

Keywords

DSGE model, Bayesian estimation, structural differences, asymmetry of shocks, posterior distribution

JEL code

C51, C68, E32

INTRODUCTION, MOTIVATION

In 2004, the Czech economy joined the European Union, and by doing this, it committed itself to join the European Monetary Union in the future. Since then, attention of the academics and the public has been focused on evaluation whether the common monetary policy is optimal for the Czech economy or not, see Hurník, Tůma and Vávra (2010).

Asymmetric shocks and structural differences are regarded to be the main causes of a potential suboptimality of common monetary policy. Asymmetry of shocks is understood as differences in timing, magnitude or persistence of macroeconomic shocks among economies. Structural differences are, on the other hand, perceived as differences in propagation mechanisms of macroeconomic shocks.

[1] The first, six-page-long draft of this paper was presented at the MME 2013 Conference and under the title *Analysis of Structural Differences and Asymmetry of Shocks using Posterior Distributions* was published in the conference proceedings, see Slanicay (2013a).

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The reason why asymmetric shocks and structural differences can cause suboptimality of common monetary policy is as follows. Business cycle fluctuations of the main macroeconomic variables are driven by macroeconomic shocks. Asymmetric shocks and/or structural differences between economies cause differences in development of their macroeconomic variables over the business cycle. Optimal currency area theory (henceforth OCA), developed by Mundell (1961) and refined by Alesina and Barro (2002), states that one of the main factors influencing suitability of common currency for a given country is a synchronization of the business cycle with the rest of the union. This idea is pretty straightforward. Optimal monetary policy should react to the business cycle fluctuations in a way that promotes macroeconomic stability and development in the country. If the business cycle fluctuations differ across the monetary union countries, the applied common monetary policy is likely to be suboptimal for some countries. Therefore, an analysis of asymmetric shocks and structural differences, as sources of different business cycle behavior, plays an important role in evaluating costs and benefits of common currency.

The goal of this paper is to examine asymmetry of shocks and structural differences between the Czech economy and the euro area. For this purpose I use New Keynesian DSGE model of two economies which I estimate on the data of the Czech economy and the euro area, using Bayesian techniques. Structural differences are examined by comparison of the posterior distributions of structural parameters. Asymmetry of shocks is examined using correlations between smoothed shocks obtained from the model estimation.

The rest of this paper proceeds as follows. The next section provides a review of the related literature. The second section describes the employed model in a brief non-technical manner. The third section briefly discusses some issues related to the estimation of the model. The fourth section contains the analysis of structural differences based on comparison of posterior distributions. The fifth section deals with the analysis of asymmetry of shocks based on correlations between smoothed shocks obtained from the model estimation. Finally, the last section concludes.

1 LITERATURE REVIEW

Much economic research is focused on the issues of asymmetric shocks and structural differences between economies because of their important role in evaluating costs and benefits of common currency. Pauer (1996) provides a non-technical overview of a role of asymmetric shocks in a debate about costs and benefits of common currency.

Several authors try to determine to what extent are shocks in the EU asymmetric. Bayoumi and Eichengreen (1992) find that shocks are significantly more asymmetric across EU countries than across US regions, which may indicate that the EU will experience problems with operating a monetary union. On the other hand, Verhoef (2003) shows that symmetries of demand and supply shocks increase over time in the EMU.

Many authors examine the extent of homogeneity in the euro area. Basically, there are two prevalent approaches: (i) extract the cyclical component from the data using some filtration technique (Hodrick-Prescott filter, band-pass filter, etc.) or time series models and compute the correlations between the corresponding detrended time series; or (ii) use time series models (e.g. SVARs) to identify demand and supply shocks. An extensive survey of the old evidence can be found in Eickmeier (2006) or de Haan et al. (2008). A more recent evidence can be found in Giannone et al. (2010). They find that business cycle is highly synchronized in case of the so-called "core" countries of the euro area (Italy, Germany, France, Belgium, Austria, and the Netherlands) while the business cycle synchronization in the rest of the euro area is much lower. Gächter et al. (2012) examine the impact of the financial crisis on the business cycle synchronization in the euro area. Their results indicate a desynchronization of business cycles during the crisis period, both with respect to dispersion and to the correlation of business cycles.

There is also a growing literature on the business cycle synchronization between the euro area and the countries of Central and Eastern Europe (henceforth CEE). An extensive survey of the old evidence can be found in Fidrmuc and Korhonen (2006) who also offer a related meta-analysis. Benčík (2011) offers a more recent evidence on the BC synchronization between the euro area and the V4 countries. He finds that prior 2001 the business cycles of the V4 countries and the euro area were not synchronised, however, there seems to be convergence of business cycles as the synchronization increases between 2001 and 2007 when the V4 countries joined the EU and increases even further during the economic crisis of 2008–2009.

Structural analysis of business cycle synchronization can be found in my previous paper, see Slanicay (2013b), where I examine such synchronization between the Czech economy and the euro area via fully-specified DSGE model. Using a two-country DSGE model I decompose the observed variables into the contributions of structural shocks and then consequently compute conditional correlations. I also examine how these correlations evolve over time. Similarly, Kolasa (2013) also reports conditional correlations between various business cycle components in the Euro Area and new member states of EU, as well as their evolution over time. The main difference is that he uses a business cycle accounting framework proposed by Chari et al. (2007) rather than a fully-specified DSGE model.

Using model comparison based on Bayes factor, several papers examine presence and relative importance of different sources of heterogeneity among economies. Jondeau and Sahuc (2007, p. 5) distinguish three main sources of heterogeneity: (i) structural heterogeneity which corresponds to differences in preferences, technology, etc.; (ii) policy heterogeneity which corresponds to differences in the conduct of economic policy; and (iii) stochastic heterogeneity which corresponds to differences in shocks hitting respective economies.[3] Jondeau and Sahuc (2007) examine sources of heterogeneity within the euro area and conclude that asymmetric shocks are the main sources of a different behavior of countries in the euro area, while structural differences play almost no role. Similar results are provided by Kolasa (2009) who investigates sources of heterogeneity between Poland and the euro area, and finds out that volatility and synchronization of shocks hitting both economies are the main sources of the heterogeneity between Poland and the euro area. Similarly, in Slanicay (2011) I examine sources of heterogeneity between the Czech economy and the euro area. I do not find substantial evidence in favor of heterogeneity in household preferences. I find slight differences in price and wage formation and substantial difference in interest rate smoothing. However, the main differences are in timing, persistence and volatility of structural shocks. Herber and Němec (2012) provide similar results. They find out that price and wage rigidities and the asymmetry of shocks are the main sources of heterogeneity between the Czech economy and the euro area. On the other hand, they find a strong evidence in favour of homogeneity in parameters describing preferences of households.

This paper has similar goal as the articles mentioned in the previous paragraph, i.e. to examine different sources of heterogeneous behavior between the Czech economy and the euro area. The main difference between this paper andthe existing literature lies in a different method employed. The articles mentioned above make use of the method based model comparison using Bayes factor while this article uses method based on comparison of posterior estimates. The idea which lies beneath the approach based on Bayes factor is following. Parameters can be modeled as common for both economies or as different for each economy. If a significant difference in the values of some parameters truly exists, then the models which allow for difference in these parameters should fit the data better than the models with common values of these parameters. I can compare the unrestricted variant of the model with the restricted variant where selected parameters are modeled as identical for both economies, and find which model fits the data better. If I find out that the unrestricted variant fits the data better, I can conclude that there

[3] Note, that both structural and policy heterogeneity influence propagation mechanisms of macroeconomic shocks among economies and thus can be included in the term "structural differences" while stochastic heterogeneity is an alternative label for asymmetric shocks.

is an evidence of structural difference in those parameters. The measure of how the model fits the data is a value of likelihood function and Bayes factor is simply the ratio of two likelihood values. It can be argued that likelihood function (and Bayes factor in turn) implicitly penalizes the richer structure of the model (i.e. the unrestricted variant) and thus potentially underestimates the significance of structural heterogeneity. The method based on comparison of posterior estimates examines structural differences per se and there should not be a bias of this kind.

2 MODEL

I use a New Keynesian DSGE model of two economies, originally presented in Kolasa (2009). I chose a two-country model because both economies are modeled in the same way there. This means that the log-linearized equations have the same structural form in both economies and the variables, parameters, and shocks have the same structural interpretation in both economies. This feature allows for consistent evaluation of structural differences between the Czech economy and the euro area.

Details about the derivation of the model can be found in the Appendix (available at the website of this journal, see the online version of the *Statistika: Statistics and Economy Journal* No. 1/2016 at: <*http://www.czso.cz/statistika_journal*>). In this section I limit my description of this model to a brief overview of its structure.

The model assumes that there are only two economies in the world: a domestic economy (represented by the Czech economy) and a foreign economy (represented by the euro area). The problematic fact that one economy is much smaller than the other is solved by parameter n, which governs the relative size of the two economies.

The next subsections offer a brief description of the domestic economy structure. The foreign economy has an identical structure. Parameters with an asterisk relate to the foreign economy.

2.1 Households

Households in a domestic economy are assumed to be homogenous and maximize its expected utility function:

$$U_t(j) = E_t \sum_{k=0}^{\infty} \beta^k \left[\frac{\varepsilon_{d,t+k}}{1-\sigma} (C_{t+k}(j) - H_{t+k})^{1-\sigma} - \frac{\varepsilon_{l,t+k}}{1+\phi} L_{t+k}(j)^{1+\phi} \right], \tag{1}$$

where E_t denotes expectations in the period t, β is a discount factor, σ is an inverse elasticity of intertemporal substitution in consumption, $H_t = hC_{t-1}$ is an external habit taken by the household as exogenous, h is a parameter of habit formation in consumption, C_t is a composite consumption index (to be defined later), ϕ is an inverse elasticity of labor supply, $\varepsilon_{d,t}$ is a preference shock in the period t, which influences intertemporal decisions about consumption and $\varepsilon_{l,t}$ is a labor supply shock in the period t.

Maximization of the utility function is subject to a set of flow budget constraints given by

$$\begin{aligned} &P_{C,t}C_t(j) + P_{I,t}I_t(j) + E_t\{\Upsilon_{t,t+1}B_{t+1}(j)\} = B_t(j) + W_t(j)L_t(j) \\ &+ R_{K,t}K_t(j) + \Pi_{H,t}(j) + \Pi_{N,t}(j) + T_t(j), \qquad \text{for} t = 0, 1, 2 \ldots, \end{aligned} \tag{2}$$

where $P_{C,t}$ denotes the price of the consumption C_t, $P_{I,t}$ is the price of investment goods I_t, B_{t+1} is the nominal payoff in period t+1 of the portfolio held at the end of period t, W_t is the nominal wage, $R_{K,t}$ denotes income of households achieved from renting capital K_t, $\Pi_{H,t}$ and $\Pi_{N,t}$ are dividends from tradable and non-tradable goods producers and T_t denotes lump sum government transfers net of lump sum taxes. $\Upsilon_{t,t+1}$ is the stochastic discount factor for nominal payoffs, such that $E_t\Upsilon_{t,t+1} = R_t^{-1}$, where R_t is the gross return on a riskless one-period bond.

Consumption index C_t consists of final tradable goods index $C_{T,t}$ and non-tradable goods index $C_{N,t}$ which are aggregated according to

$$C_t = \frac{C_{T,t}^{\gamma_c} C_{N,t}^{1-\gamma_c}}{\gamma_c^{\gamma_c}(1-\gamma_c)^{1-\gamma_c}}, \tag{3}$$

where γ_c denotes share of final tradable goods in consumption of households. Following Burstein et al. (2003) and Corsetti and Dedola (2005), it is assumed that consumption of a final tradable good requires ω units of distribution services $Y_{D,t}$, which implies

$$C_{T,t} = \min\{C_{R,t}; \omega^{-1} Y_{D,t}\}. \tag{4}$$

The consumption index of raw tradable goods is defined as

$$C_{R,t} = \frac{C_{H,t}^{\alpha} C_{F,t}^{1-\alpha}}{\alpha^{\alpha}(1-\alpha)^{1-\alpha}}, \tag{5}$$

where α denotes share of domestic goods in the domestic basket of tradable goods, $C_{H,t}$ is an index of home-made tradable goods and $C_{F,t}$ is an index of foreign-made tradable goods, both consumed in the domestic economy and defined as

$$C_{H,t} = \left[\left(\frac{1}{n}\right)^{\frac{1}{\phi_H}} \int_0^n C_t(z_H)^{\frac{\phi_H - 1}{\phi_H}} \mathrm{dz_H}\right]^{\frac{\phi_H}{\phi_H - 1}}, \tag{6}$$

$$C_{F,t} = \left[\left(\frac{1}{1-n}\right)^{\frac{1}{\phi_F}} \int_n^1 C_t(z_F)^{\frac{\phi_F - 1}{\phi_F}} dz_F\right]^{\frac{\phi_F}{\phi_F - 1}}, \tag{7}$$

where ϕ_H (ϕ_F) is an elasticity of substitution between domestic (foreign) tradable goods, consumed in the domestic economy. Analogously, the consumption index of non-tradable goods is defined as

$$C_{N,t} = \left[\left(\frac{1}{n}\right)^{\frac{1}{\phi_N}} \int_0^n C_t(z_N)^{\frac{\phi_N - 1}{\phi_N}} dz_N\right]^{\frac{\phi_N}{\phi_N - 1}}, \tag{8}$$

where ϕ_N is an elasticity of substitution between domestic non-tradable goods.

Households use part of their income to accumulate capital K_t, assumed to be homogenous, which they rent to firms. Capital is accumulated according to the formula:

$$K_{t+1} = (1-\tau)K_t + \varepsilon_{i,t}\left(1 - S\left(\frac{I_t}{I_{t-1}}\right)\right)I_t, \tag{9}$$

where τ is a depreciation rate of capital and I_t denotes investment in the period t. Following Christiano et al. (2005), capital accumulation is subject to investment specific technological shock $\varepsilon_{i,t}$ and adjustment costs represented by function $S(\cdot)$. This function has to satisfy following properties $S(1) = S'(1) = 0$ and $S''(\cdot) = S''> 0$.

Homogenous investment goods are produced in the same way as the final consumption goods, which implies the following definitions:

$$I_t = \frac{I_{R,t}^{\gamma_i} I_{N,t}^{1-\gamma_i}}{\gamma_i^{\gamma_i}(1-\gamma_i)^{1-\gamma_i}}, \tag{10}$$

$$I_{R,t} = \frac{\mathrm{I}_{H,t}^{\alpha} I_{F,t}^{1-\alpha}}{\alpha^{\alpha}(1-\alpha)^{1-\alpha}}. \tag{11}$$

It is assumed that a composition of consumption and investment basket in a given economy can differ, i.e. parameters γ_c and γ_i can be different, and that composition of tradable baskets is identical, i.e. parameter α is the same for both tradable consumption goods and tradable investment goods in the given economy.

Each household is specialized in a different type of labor $L_t(j)$, which it supplies in a monopolistically competitive labor market. All supplied labor types are aggregated into homogenous labor input L_t according to the formula

$$L_t = \left[\left(\frac{1}{n}\right)^{\frac{1}{\phi_W}} \int_0^n L_t(j)^{\frac{\phi_W - 1}{\phi_W}} dj\right]^{\frac{\phi_W}{\phi_W - 1}}, \tag{12}$$

where ϕ_W is the elasticity of substitution between different labor types. A corresponding aggregate wage index is then defined as

$$W_t = \left[\frac{1}{n}\int_0^n W_t(j)^{1-\phi_W} dj\right]^{\frac{1}{1-\phi_W}}, \tag{13}$$

where $W_t(j)$ denotes a wage of the household j.

Following Erceg, Henderson and Levin (2000), a wage setting mechanism a-la Calvo is assumed. According to this set-up, every period only $1-\theta_W$ portion of households (randomly chosen) can reset their wages optimally, while the remaining portion of households θ_W remain their wages unchanged.

2.2 Firms

There is a continuum of homogenous, monopolistic competitive firms in the tradable and non-tradable sectors of the domestic economy. The production functions of firms are represented by Cobb-Douglas functions, homogenous in labor and capital of degree one (i.e. with constant returns to scale):

$$
\begin{aligned}
Y_t(z_N) &= \varepsilon_{a^N,t} L_t(z_N)^{1-\eta} K_t(z_N)^{\eta}, \\
Y_t(z_H) &= \varepsilon_{a^H,t} L_t(z_H)^{1-\eta} K_t(z_H)^{\eta},
\end{aligned}
\tag{14}
$$

where η is the elasticity of output with respect to capital (common to both sectors, but potentially different in individual countries), and $\varepsilon_{a^H,t}$ ($\varepsilon_{a^N,t}$) is a productivity shock in the tradable (non-tradable) sector.

Firms set their prices in order to maximize their profits. It is assumed that firms face modified Calvo restriction on the frequency of price adjustment. According to this restriction, every period only $1-\theta$ portion of firms (randomly chosen) can reset their prices optimally, while θ portion of firms remain their prices unchanged.

It is assumed that prices are set in the producer's currency and that international law of one price holds for intermediate tradable goods. Thus, prices of domestic goods sold in the foreign economy and prices of foreign goods sold in the domestic economy are given by formulas:

$$
P_t^*(z_H) = ER_t^{-1} P_t(z_H) \qquad P_t(z_F) = ER_t P_t^*(z_F), \tag{15}
$$

where ER_t is the nominal exchange rate expressed as units of domestic currency per one unit of foreign currency.

2.3 International Risk Sharing

The assumption of complete financial markets implies that expected nominal returns on domestic and foreign bonds must be the same, which implies the following condition:

$$
Q_t = \kappa \frac{\varepsilon_{d,t}^*}{\varepsilon_{d,t}} \frac{(C_t^* - h^* C_{t-1}^*)^{-\sigma^*}}{(C_t - hC_{t-1})^{-\sigma}}, \tag{16}
$$

where κ is a constant depending on initial conditions and Q_t is a real exchange rate defined as

$$
Q_t = \frac{ER_t P_{C,t}^*}{P_{C,t}}. \tag{17}
$$

The real exchange rate can deviate from purchasing power parity because of changes in relative prices of tradable and non-tradable goods, changes in relative distribution costs and changes in terms of trade, as long as there is a difference between household preferences among countries, i.e. $\alpha \neq 1-\alpha^*$.

$$
Q_t = S_t^{\alpha+\alpha^*-1} \frac{1+\omega^* D_t^*}{1+\omega D_t} \frac{X_t^{*1-\gamma_c^*}}{X_t^{1-\gamma_c}}, \tag{18}
$$

where S_t are terms of trade defined as domestic import prices relative to domestic export prices[4]

$$
S_t = \frac{ER_t P_{F,t}^*}{P_{H,t}}, \tag{19}
$$

[4] The assumption of law of one price for tradable goods implies $S_t^* = S_t^{-1}$.

X_t and $X_t^*$are internal exchange rates defined as prices of non-tradable goods relative to prices of tradable goods

$$X_t = \frac{P_{N,t}}{P_{T,t}} \qquad X_t^* = \frac{P_{N,t}^*}{P_{T,t}^*} \tag{20}$$

and D_t and $D_t^*$are relative distribution costs, defined as prices of non-tradable goods relative to prices of raw tradable goods

$$D_t = \frac{P_{N,t}}{P_{R,t}} \qquad D_t^* = \frac{P_{N,t}^*}{P_{R,t}^*}. \tag{21}$$

2.4 Monetary and Fiscal Authorities

The behavior of central bank is described by a variant of Taylor rule:

$$R_t = R_{t-1}^{\rho}\left[E_t\left\{\left(\frac{Y_{t+1}}{\overline{Y}}\right)^{\varphi_y}\left(\frac{P_{C,t+1}}{(1+\overline{\pi})P_{C,t}}\right)^{\varphi_\pi}\right\}\right]^{1-\rho}\varepsilon_{m,t}, \tag{22}$$

where ρ is a parameter of interest rate smoothing, Y_t is a total output in the economy, $\overline{Y}$ denotes a steady state level of this output, $\overline{\pi}$ is a steady state level of inflation, ϕ_y is an elasticity of the interest rate to the output, ϕ_π is an elasticity of the interest rate to inflation and $\varepsilon_{m,t}$ is a monetary policy shock.

Fiscal policy is modeled in a very simple fashion. Government expenditures and transfers to households are fully financed by lump-sum taxes so that the state budget is balanced every period. Government expenditures consist only of non-tradable domestic goods and are modeled as a stochastic AR1 process $\varepsilon_{g,t}$. Given the assumptions about households, Ricardian equivalence holds in this model.

2.5 Market Clearing Conditions

The model is closed by satisfying the market clearing conditions. Goods market clearing requires that output of each firm producing non-tradable goods is either consumed by households in the domestic economy, spent on investment, used for distribution services or purchased by the government. Similarly, output of firms producing tradable goods is either consumed or invested in the domestic or foreign economy. Formally:

$$Y_{N,t} = C_{N,t} + I_{N,t} + Y_{D,t} + G_t, \tag{23}$$

$$Y_{H,t} = C_{H,t} + C_{H,t}^* + I_{H,t} + I_{H,t}^*. \tag{24}$$

The total output in the economy is given by the sum of output in tradable and non-tradable sectors:

$$Y_t = Y_{N,t} + Y_{H,t}. \tag{25}$$

Finally, market clearing conditions for factor markets requires

$$L_t = \int_0^n L_t(z_N)dz_N + \int_0^n L_t(z_H)dz_H \tag{26}$$

$$K_t = \int_0^n K_t(z_N)dz_N + \int_0^n K_t(z_H)dz_H. \tag{27}$$

2.6 Exogenous Shocks

Business cycle behavior of the model is driven by seven structural shocks in each economy: productivity shocks in tradable sector ($\varepsilon_{a^H,t}$ and $\varepsilon_{a}^{*}{}_{F,t}$), productivity shocks in non-tradable sector ($\varepsilon_{a^N,t}$ and $\varepsilon_{a}^{*}{}_{N,t}$), labor supply shocks ($\varepsilon_{l,t}$ and $\varepsilon^{*}_{l,t}$), investment efficiency shocks ($\varepsilon_{i,t}$ and $\varepsilon^{*}_{i,t}$), consumption preference shocks ($\varepsilon_{d,t}$ and $\varepsilon^{*}_{d,t}$), government spending shocks ($\varepsilon_{g,t}$ and $\varepsilon^{*}_{g,t}$) and monetary policy shocks ($\varepsilon_{m,t}$ and $\varepsilon^{*}_{m,t}$).

Except for monetary policy shocks which are represented by IID processes, all other shocks are represented by AR1 processes in the log-linearised version of the model. I allow for correlations between innovations of corresponding shocks in both economies.

3 ESTIMATION

3.1 Data

For the estimation of the model I used the quarterly data of the Czech economy and the euro area-17 economy from the 1st quarter of 2000 to the 1st quarter of 2014. The data series were downloaded from the Eurostat web database. I used the following 14 time series (seven for each economy): real GDP, consumption, investment, the HICP, the real wage, the short-term interest rate, and the internal exchange rate (defined as prices of non-tradable goods relative to prices of tradable goods). Except for nominal interest rates, all the observed variables are seasonally adjusted and expressed as demeaned 100∗log differences. Nominal interest rates are demeaned and expressed as quarterly rates in percent.[5]

The model is estimated with Random Walk Chain Metropolis-Hastings algorithm, using Dynare toolbox for Matlab, version 4.2.4.[6] I generated two independent chains, each with 2 000 000 draws. From each chain I used only 25% of last draws in order to get rid of the influence of different initial values of the parameters in each chain. Average acceptance rate in each chain is about 29%, which is in line with the informal recommendation about ideal acceptance rate, see for example Koop (2003).

3.2 Calibration

Because of a large number of parameters and a short length of the data sample employed, I decided to calibrate a few parameters. I calibrated those parameters for which I have a good prior information from the data, and those parameters which are known to be weakly identifiable in DSGE models. This mixed approach is quite common in the literature and leads to a better identifiability of non-calibrated parameters, see Canova (2007).

The parameter n governing the relative size of both economies is calibrated to be 0.0138, according to the ratio of nominal GDP levels, averaged over the examined period. The share of tradable goods in consumption in the Czech economy γ_c (in the Euro Area 17γ^{*}_{c}) is calibrated to be 0.5384 (0.4953). These values correspond to the complements of the average shares of services and energy goods in the HICP baskets in the examined period. Parameters γ_i and γ^{*}_{i}, which denote the share of tradable

[5] More details about the data and their visual representation can be found in the Appendix (available at the website of the *Statistika: Statistics and Economy Journal* in the online version of the No. 1/2016 at: <*http://www.czso.cz/statistika_journal*>).

[6] More details about Dynare toolbox as well as the Dynare code of the model can be found in the Appendix (see online version of the No. 1/2016 of the *Statistika: Statistics and Economy Journal* at: <*http://www.czso.cz/statistika_journal*>).

[7] The portion of discarded draws was set according to Markov Chain Monte Carlo convergence diagnostics which can be found in the Appendix (see online version of the No. 1/2016 of the *Statistika: Statistics and Economy Journal* at: <*http://www.czso.cz/statistika_journal*>).

investment goods, are set equal to 0.5006 and 0.4257, according to the average shares of investment expenditures other than construction works and cultivated assets in the examined period. The shares of domestic tradable goods α and α^* are set equal to 0.28 and 0.989, following Musil (2009).

The discount factors β and β^* are calibrated to be 0.9975, which implies an annual steady state real interest rate of . This value roughly corresponds to the long term mean of annual real interest rates in both economies. Quarterly depreciation rates τ and τ^* are calibrated to be 0.025, which implies an annual depreciation rate of 10%. Distribution costs ω and ω^* are calibrated to zero which implies no share of distribution services in the tradable goods. Elasticities of output with respect to capital η and η^* are calibrated at 0.4160 and 0.3618, which corresponds to the complement to the average shares of labor on the GDP in the given economy in the period 2000–2010.[8] Elasticities of substitution among labor types ϕ_W and ϕ^*_W, which are known to be badly identifiable, are set equal to 3 following Smets and Wouters (2003). This value implies a wage mark-up of 50%. Following Slanicay and Vašíček (2011), Čapek (2010) and Matheson (2010), who argue that incorporating price (wage) indexation into the Calvo price (wage) setting mechanism deteriorates the empirical fit of DSGE models, I decided to set indexation parameters δ_H, δ^*_F, δ_N, δ^*_N, δ_W and δ^*_W equal to 0. It implies that the estimated variant of the model employs the original Calvo price (wage) setting mechanism, see Calvo (1983).

Steady state shares of consumption, investment and government spending in the total output correspond to their average shares in the GDP in the examined period. Namely, $\frac{\overline{C}}{\overline{\overline{Y}}} = 0.4929$, $\frac{\overline{I}}{\overline{\overline{Y}}} = 0.2590$, $\frac{\overline{C^*}}{\overline{\overline{Y^*}}} = 0.5681$ and $\frac{\overline{I^*}}{\overline{\overline{Y^*}}} = 0.1999$. Other steady state shares are calculated consistently with the derivation of the model (analogously for the foreign economy):

$$\frac{\overline{G}}{\overline{\overline{Y}}} = 1 - \frac{\overline{C}}{\overline{\overline{Y}}} - \frac{\overline{I}}{\overline{\overline{Y}}}, \tag{28}$$

$$\frac{\overline{Y_N}}{\overline{\overline{Y}}} = \frac{1+\omega-\gamma_c}{1+\omega}\frac{\overline{C}}{\overline{\overline{Y}}} + (1-\gamma_i)\frac{\overline{I}}{\overline{\overline{Y}}} + \frac{\overline{G}}{\overline{\overline{Y}}}, \tag{29}$$

$$\frac{\overline{Y_H}}{\overline{\overline{Y}}} = 1 - \frac{\overline{Y_N}}{\overline{\overline{Y}}}. \tag{30}$$

3.3 Prior Setting

Remaining parameters are estimated. For parameters whose natural domain is the interval between 0 and 1, I chose Beta distribution of priors. For structural parameters whose natural domain is the set of non-negative real numbers, I chose Gamma distribution of priors, except for the parameters of adjustment costs S^*, S^{**}. For those I chose Normal distribution of priors. For parameters representing standard deviations of shocks, whose natural domain is the set of non-negative real numbers, I chose Inverse Gamma distribution of priors. For parameters representing spillovers of the foreign shocks, whose natural domain are real numbers, I chose Normal distribution of priors.

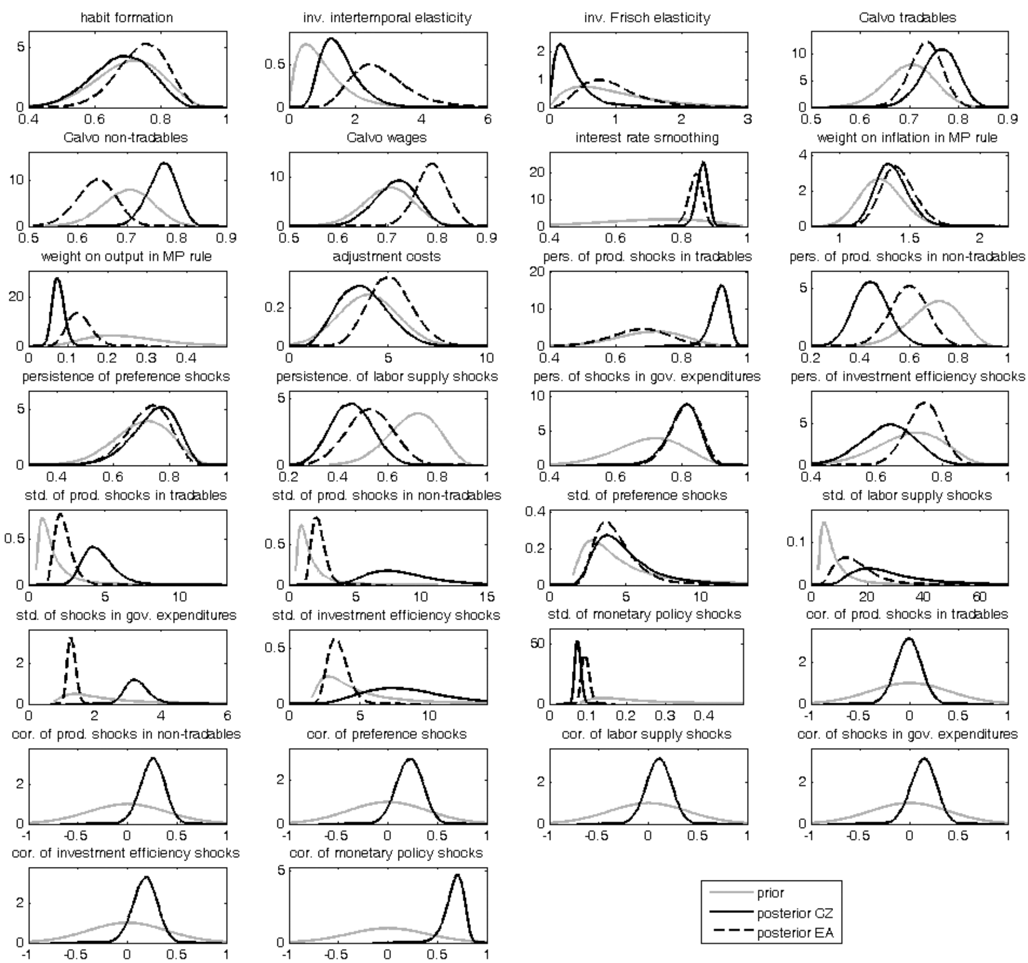
Prior means for Calvo parameters of price and wage stickiness θ_H, θ^*_F, θ_N, θ^*_N, θ_W and θ^*_W are set to be 0.7 which implies the average price (wage) duration of 10 months. Priors for parameters in the Taylor rule are set consistently with Taylor (1999). Inverse elasticities of intertemporal substitution σ and σ^* and inverse Frisch elasticities of labor supply ϕ ϕ^* are estimated with relatively loose priors with prior means set to be 1.0, following Galí (2008), and prior std. deviations equal to 0.7, which are values commonly

[8] See: <*http://stats.oecd.org*>.

found in the business cycle literature. Parameters of habit formation h and h^* are estimated with prior means set to be and prior std. deviations equal to , as in Smets and Wouters (2003). Priors for capital adjustment costs S^* and S^{**} are taken from Kolasa (2009). Priors for shocks are taken from Herber and Němec (2012).

Figure 1 depicts the prior and posterior distributions of the estimated parameters so the readers get some idea on how well are the parameters identified in the data. We can see that there is a substantial, though not perfect, overlap of prior and posterior distributions which may suggest either that prior distributions are well chosen or that there is not enough information about the parameters in the data. In most cases, however, posterior distributions are either not overlapping so heavily with prior distributions or are more tight than prior distributions which suggest that the data bear some information regarding the estimated parameters.

Figure 1 Priors and Posteriors



Source: Own construction

4 ANALYSIS OF STRUCTURAL PARAMETERS

Structural differences manifest themselves as significant differences in values of some parameters. As the estimates of parameters are given by their posterior distributions, see Figure 1, it seems therefore intuitive to compare posterior distributions of corresponding parameters in both economies and evaluate how much they overlap.[9]

There are many ways how to evaluate the overlap of posterior distributions. I use the following five criteria.[10] The benchmark criterion is the overlapping area of normalized posterior densities, henceforth denoted as *area*. The obtained number must lie between zero and one, where zero means that densities do not have single common point while unity means identical densities. The next four criteria use credible intervals in various specifications. The criterion *s_2S* is based on two-sided probability band and measures the lowest level of significance at which two-sided probability bands do not overlap. Similarly, the criterion *s_HPD* denotes the lowest level of significance at which the highest posterior density intervals do not overlap. The last two criteria are based on point estimates. The criterion *s_med* denotes the lowest level of significance at which posterior median is out of two-sided probability bands, while the criterion *s_mod* denotes the lowest level of significance at which posterior mode is out of HPD interval bands.[11] The possible values of all five criteria range from zero to one, where zero represents absolute asymmetry in the parameter values while unity represents absolute symmetry in the parameter values.

The reason for multiple criteria is the following: the benchmark criterion *area* may in certain circumstances deliver a strange result. It may happen that calculated *area* of two posterior distributions can be very low although their central tendencies (represented for example by posterior mean) are the same. It is the case when the main difference between two posterior distributions lies in different identifiability of these two parameters and, therefore, in different uncertainty connected with posterior estimates.

Table 1 displays calculated criteria of the overlap of posterior distributions, ordered from the lowest *area* to the highest. The biggest difference lies in the degree of price stickiness in the non-tradable sector, with *area* = 0.05. It seems that domestic prices of non-tradable goods are much more sticky than foreign prices of non-tradable goods. Point estimates[12] imply that the average duration of domestic prices of non-tradable goods is about 13 months, while the average duration of foreign prices of non-tradable goods is only 8.2 months.

The second biggest difference is in the way how central banks react to the development of output, with *area* = 0.22. It seems that unlike the Czech National Bank (henceforth CNB), the ECB reacts more to the development of output. Point estimates imply that one percent deviation of output from the steady state (trend) brings about change in the interest rate of 0.041% in the Czech economy, and 0.081% in the euro area.

The third biggest difference is in the degree of wage stickiness, with area = 0.32. Results suggest that wages in the Czech economy are less sticky than wages in the euro area. Point estimates imply that the average duration of wage is 10.5 months in the Czech economy, and 14.1 months in the euro area.

There is also a big difference in the inverse Frisch elasticity of labor supply, with *area* = 0.35. It seems that labor supply in the Czech economy is more elastic than labor supply in the euro area. Point estimates imply that the 1% increase of the real wage induces 2.9% increase of the labor

9 This type od analysis can be also used for identification of structural changes in an economy, see Čapek (2016) who applies this approach on the Czech economy data.

10 Formal definition od these criteria can be found in the Appendix (see online version of the No. 1/2016 of the *Statistika: Statistics and Economy Journal* at: *http://www.czso.cz/statistika_journal*).

11 Note that both criteria *s_med* and *s_mod* deliver two values – one for a domestic parameter and one for a foreign parameter.

12 Point estimates are represented by the estimated posterior mean.

Table 1 Overlap of Posterior Distributions

structural parameters	*area*	*s_2S*	*s_HPD*	*s_med*	*s_mod*
price stickiness of non-tradables	0.05	0.06	0.06	0.01 0.01	0.01 0.01
weight on output in MP rule	0.22	0.23	0.25	0.01 0.05	0.01 0.05
wage stickiness	0.32	0.33	0.36	0.06 0.04	0.07 0.05
inverse elasticity of labor supply	0.35	0.36	0.35	0.11 0.07	0.09 0.06
inverse elasticity of intertemporal subs.	0.36	0.37	0.37	0.08 0.07	0.08 0.06
adjustment costs	0.55	0.57	0.54	0.29 0.19	0.24 0.18
interest rate smoothing	0.58	0.57	0.59	0.26 0.28	0.23 0.30
price stickiness of tradables	0.67	0.68	0.65	0.46 0.36	0.46 0.32
habit formation in consumption	0.71	0.71	0.70	0.48 0.44	0.53 0.36
weight on inflation in MP rule	0.84	0.84	0.82	0.70 0.69	0.65 0.67

Source: Own calculation

supplied in the Czech economy, while in the euro area the 1% increase of the real wage induces only 1% increase of the labor supplied.[13]

There is also a difference related to the inverse elasticity of intertemporal substitution, with *area* = 0.36. It suggests that domestic households are less willing to smooth consumption over the time then their foreign counterparts.

The overlapping *area* of remaining parameters is higher than 0.5, which suggests that differences in these parameters are less significant. However, there are still some interesting differences which are worth interpreting. It seems that domestic prices in the tradable sector are more sticky than foreign prices in the tradable sector. Point estimates imply that the average duration of prices in the tradable sector is 12.5 months in the Czech economy, and 11.2 months in the euro area.

Other structural differences are related to the parameters in the monetary policy rule, namely the degree of interest rate smoothing and the way how central banks react to the development of inflation. It seems that the ECB smooths its interest rate less than the CNB does and that the ECB reacts more to the development of inflation than the CNB does. Point estimates imply that one percent deviation of inflation from the steady state (trend) induce a change in the interest rate of 0.75% in the Czech economy and 0.9% in the euro area.

5 ANALYSIS OF ASYMMETRY OF SHOCKS

Except for monetary policy shocks, the shocks in the Czech economy are more volatile than the same kind of shocks in the euro area, see Figure 1. Volatility of monetary policy shocks is little bit larger in the euro area than in the Czech economy, nevertheless, the differences in the estimated posterior means are almost negligible.

[13] One need to be very careful with the interpretation of the results for the elasticity of labor supply. Firstly, it is well-known fact that estimates of the elasticity of labor supply obtained from macro data are usually much higher than estimates based on micro data, for a discussion of this topic see Chetty et al. (2011), Peterman (2012) or Reichling and Whalen (2012). Secondly, as the posterior distributions of the other structural parameters are more or less centred, it does not matter whether we choose as the point estimate the posterior mean, posterior mode or posterior median. However, in the case of the inverse Frisch elasticity of labor supply the posterior distributions are highly skewed, see Figure 1, which imply a very different values for the posterior mean, posterior mode and posterior median. In particular, posterior mean is higher than posterior median which is higher than posterior mode. Nevertheless, the result that labor supply in the Czech economy is more elastic than labor supply in the euro area seems to be robust among these different point estimates.

As regards the correlations between corresponding shocks in both economies, for obvious reasons it can not be analysed via the method based on the overlap of posterior distributions. Therefore, I decided to analyse these correlations via their point estimates obtained from smoothed realisations of the shocks. Table 1 displays correlations between corresponding innovations in the shocks and, except for the monetary policy shocks which are modeled as IID processes, correlations between the corresponding whole shocks represented by AR1 processes.

Table 2 Estimated Correlations between Shocks

structural shocks	correlation (p value)	
	innovation	**AR1**
consumption preference shocks	0.22 (0.10)	0.82 (0.00)
monetary policy shocks	0.66 (0.00)	n.a.
shocks in investment efficiency	0.20 (0.14)	0.64 (0.00)
productivity shocks in non-tradables	0.30 (0.03)	0.57 (0.00)
productivity shocks in tradables	–0.04 (0.79)	0.35 (0.01)
labor supply shocks	0.15 (0.29)	0.33 (0.01)
shocks in government expenditures	0.16 (0.23)	–0.18 (0.18)

Source: Own calculation

If we are interested in the asymmetry of shocks actually hitting the economies, then we should pay more attention to the correlations between the corresponding whole shocks, presented in the last column of the Table 1.[14] We can see that the whole shocks are much more correlated than the corresponding innovations, thus suggesting that shocks are less asymmetric than what would the correlations between innovations imply.

The most correlated shocks are (ordered from the highest correlation to the lowest) consumption preference shocks (cor = 0.82), monetary policy shocks (cor = 0.66), investment efficiency shocks (cor = 0.64), and productivity shocks in the non-tradable sector (cor = 0.57). Correlations of these shocks are quite high, all of them are statistically significant on the significance level $\alpha = 0.01$. We can say that these shocks are quite symmetric between the Czech economy and the euro area. On the other hand, the shocks with the lowest correlations are (ordered from the lowest correlation to the highest) shocks in government expenditures (cor = –0.18), labor supply shocks (cor = 0.33), and productivity shocks in the tradable sector (cor = 0.35). These shocks can be regarded as asymmetric between the Czech economy and the euro area.

CONCLUSION

In this paper I examined asymmetry of shocks and structural differences between the Czech economy and the euro area. For this purpose I used New Keynesian DSGE model of two economies, originally presented in Kolasa (2009). The model is estimated on the data of the Czech economy and the euro area, using Bayesian techniques.

Structural differences are examined via the overlap of posterior distributions of structural parameters. Results suggest that prices in the Czech economy are more sticky than prices in the euro area,

[14] In Kolasa (2009), which is the reference paper for the model employed in this paper, the asymmetry of shocks is analysed using correlations between corresponding innovations in the shocks. From my point of view, these results might be misleading because these correlations are only between innovations and not between shocks actually hitting the economies. I view the results based on the correlations between the whole shocks (in most cases represented by AR1 process) as more meaningful.

especially in the non-tradable sector, while wages are more sticky in the euro area than in the Czech economy. It seems that the ECB smooths less the interest rate and reacts more to the development in output and inflation than the CNB. It also seems that labor supply in the Czech economy is more elastic than labor supply in the euro area. Results also suggest that Czech households are less willing to smooth consumption over the time then their foreign counterparts.

Asymmetry of shocks is examined using correlations between smoothed shocks obtained from the model estimation. Except for monetary policy shocks, the shocks in the Czech economy are more volatile than the same kind of shocks in the euro area. The most asymmetric shocks are shocks in government expenditures, labor supply shocks, and productivity shocks in the tradable sector, while the most symmetric shocks are consumption preference shocks, monetary policy shocks, and investment efficiency shocks. Productivity shocks in the non-tradable sector can be regarded as moderately symmetric.

ACKNOWLEDGMENT
This work was supported by funding of specific research at ESF MU, project MUNI/A/1049/2015. I also thank Jan Brůha, Jan Čapek, Mirek Hloušek, and two anonymous *Statistika Journal* reviewers for helpful comments and suggestions.

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APPENDIX

See the separate PDF file in online version of the *Statistika: Statistics and Economy Journal* No. 1/2016 at: <*http://www.czso.cz/statistika_journal*>.

Minimal Adequate Model of Unemployment Duration in the Post-Crisis Czech Republic

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Abstract

Unemployment is one of the leading economic problems in a developed world. The aim of this paper is to identify the differences in unemployment duration in different strata in the post-crisis Czech Republic via building a minimal adequate model, and to quantify the differences.

Data from Labour Force Surveys are used and since they are interval censored in nature, proper methodology must be used. The minimal adequate model is built through the accelerated failure time modelling, maximum likelihood estimates and likelihood ratio tests.

Variables at the beginning are sex, marital status, age, education, municipality size and number of persons in a household, containing altogether 29 model parameters. The minimal adequate model contains 5 parameters and differences are found between men and women, the youngest category and the rest and the university educated and the rest. The estimated expected values, variances, medians, modes and 90$^{\text{th}}$ percentiles are provided for all subgroups.

Keywords

Unemployment duration, Labour Force Survey, minimal adequate model, interval censoring, AFT model

JEL code

J64, C24

INTRODUCTION

Unemployment is one of the leading problems in economy in a developed world and thus rightly the object of interest to many people. As usual, the problem of unemployment is statistically described by an unemployment rate and, regarding the duration of unemployment, a rate of long-term unemployment, i.e. the proportion of those who are unemployed longer than one year to all unemployed, is used (Eurostat, 2015b; CZSO, 2015).

Statistics about average unemployment duration for selected countries are provided by OECD (OECD. Stat, 2015). A deeper look at the unemployment duration in the Czech Republic was provided e.g. in Jarošová et al. (2004), Jarošová (2006) and more recently in Čabla (2014, 2015) and Malá (2013, 2014).

Main findings in previously cited papers are the changing role of possible explanatory variables. During the crisis the unemployment duration was influenced by sex, marital status, number of persons in household and education. After the crisis the unemployment duration was influenced only by sex and education, so we can see diminishing importance of marital status and number of persons in household.

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The current paper newly provides multivariable model how to deconstruct possible dependence between these variables and to confirm or reject previous findings via more sound methodology.

Data are obtained from the Labour Force Survey (LFS), which is a large household sample survey providing quarterly results on labour participation of people aged 15 and over as well as on persons outside the labour force (Eurostat, 2015a).

The main problem in modeling the unemployment duration and obtaining its characteristics lies in the fact, that the data from LFS are censored. A researcher must consider it and use proper methodology based on a survival analysis. Some deeper methodological sources are provided in Čabla (2012).

The current paper offers an evaluation of the post-crisis data, specifically the year 2014. The main aim is to provide the minimal adequate model of the unemployment duration.

1 DATA

Data come from the LFS from quarters Q4/2013–Q1/2014. The LFS is conducted quarterly and 20% of the participants are changed every quarter. In other words, each participant takes part in five consecutive surveys. One survey includes approximately 50–60 thousand of participants.

One of the questions refers to the duration of a job search and another one the duration of current job. As a person is questioned over a year and a quarter, one can find those, who obtained a job in this survey period and compute the search duration. All participants were checked on their entry to the LFS and in the end of their participation. As the answers to the stated questions are interval censored, so is the consequent duration. Finally, 673 of participants who found a job were found.

It is important to keep in mind that the paper deals only with the unemployment duration of the participants, who were unemployed to begin with (unlike being economically inactive) and then found a job.

Possible explanatory variables for a model building, their shortcuts and base values are in the Table 1. Codes and numbers of observations for each category of the explanatory variables are in the annex in the Tables A1–A6. The Unemployment duration is given in months.

Table 1 Explanatory variables, their coding and base value

Explanatory variable	Shortcut	Base value
Number of persons in the household	PocOD	2
Sex	Pohl	1
Marital status	RodStav	1
Age group	VekSk	2
Education according to the ISCED scale	ISCED	3
Municipality size	MuniSize	2

Source: CZSO, own construction

2 METHODOLOGY

The main feature of the dataset is that the variable of interest – the unemployment duration, has only interval or right censored values. Standard methodology for dealing with censored variables is survival analysis.

2.1 Probability distribution in survival analysis

The main form of a description of a probability distribution in survival analysis, is a survival function. The survival function gives the probability that random variable T exceeds the specified time t.

$$S(t) = P(T > t) = 1 - F(t). \tag{1}$$

The second description of a probability distribution that is often used in survival analysis, is a hazard function. The hazard function $h(t)$ gives the instantaneous potential per unit time for the event to occur, given that the individual has survived up to time t. In any analysis survival function can be transformed to hazard function or vice versa.

$$h(t) = l\ \underset{\Delta t \to 0}{im} \frac{P(t \leq T < t + \Delta t \mid T \geq t}{\Delta t} = -\frac{dS(t)/dt}{S(t)} = \frac{f(t)}{S(t)}. \tag{2}$$

Being more specific here, the random variable T is the time of looking for a job of an unemployed person. The survival function $S(t)$ is the probability, that an unemployed person has not found a job at time t and finally the hazard function $h(t)$ is the instantaneous potential that an unemployed person will search for a job given that he has not found it up to time t (Kleinbaum and Klein, 2012).

2.2 Interval censoring

Data are called censored when exact value is not known, but they are known to fall within some interval (Li, Ri]. If only Li is known, than it is the case of right censoring. If only Ri is known, than it is the case of left censoring. If both Li and Ri are known, than it is interval censored variable.

Survival analysis is most detailed for the cases of right censoring, which usually occurs because the experiment ends before the specific event occurs. Here it means that when a person drops out from the LFS before finding a job, he can be assumed right censored as we can know only that the duration of his unemployment is longer than some specific time period Li (Kleinbaum and Klein, 2012).

2.3 Accelerated Failure Time model

Accelerated Failure Time (AFT) model is parametric survival model in which survival time is assumed to follow a known distribution. The underlying assumption of the AFT models is that the effect of covariates is multiplicative with respect to survival time.

The regression model is considered in the form:

$$\log(T) = \mu + \mathbf{x}'\boldsymbol{\beta} + \sigma\varepsilon, \tag{3}$$

where μ is an intercept, σ is a scale parameter, $\boldsymbol{\beta}$ is a vector of regression parameters, $\boldsymbol{x}$ is a vector of explanatory variables and ε is an error term with a known distribution. This can be used in

$$S(t) = P[(\mu + x'\beta' + \sigma\varepsilon) \geq \log(t)] = P\left(\varepsilon \geq \frac{\log(t) - \mu - \mathbf{x}'\boldsymbol{\beta}}{\sigma}\right), \tag{4}$$

$$S(t \mid \mathbf{x}) = S_0\left(\frac{\log(t) - \mu - \mathbf{x}'\boldsymbol{\beta}}{\sigma}\right), \tag{5}$$

where S_0 is an independent survival function of the distribution of ε and $\boldsymbol{x}'\boldsymbol{\beta}$ defines the location of T, referred to as an accelerated factor. It can be formulated with respect to the random variable T instead of $\log(T)$:

$$T = \exp(\mu + \mathbf{x}'\boldsymbol{\beta})\exp(\sigma\varepsilon), \tag{6}$$

$$S(t) = P(T \geq t) = P[\exp(\mu + \mathbf{x}'\boldsymbol{\beta} + \sigma\varepsilon \geq t)], \tag{7}$$

$$S(t|x) = S_0\left[t\exp\left(-\mathbf{x}'\boldsymbol{\beta}\right)\right]. \tag{8}$$

In the AFT models, the effect of explanatory variables is such that if $\exp(\boldsymbol{x}'\boldsymbol{\beta}) > 1$, the effect of vector $\boldsymbol{x}$ is to decelerate the survival process and if $\exp(\boldsymbol{x}'\boldsymbol{\beta}) < 1$, the effect of vector $\boldsymbol{x}$ is to accelerate the survival process. The individual terms $\exp(b_m)$ indicates the multiplicative effect of a 1-unit change of the explanatory variable x_m on the time scale.

It follows from the previous that the AFT models can be used to model dependence of random variable T on a vector of explanatory variables with clear and simple description of this dependence, which is very convenient for the use in survival analysis.

Model is estimated via maximizing likelihood function. In the case of censoring the additional assumption is that censored times are independent of each other and of actual survival times, which should be fulfilled in the dataset of unemployed. For interval censoring the likelihood function is

$$L(\boldsymbol{\theta}) = \prod_{i=1}^{n}\left[F(u_i) - F(v_i)\right] = \prod_{i=1}^{n}\left[S(v_i) - S(u_i)\right], \tag{9}$$

where $S(t; \boldsymbol{\theta})$ is the parametric survival function and u_i and v_i are defined by

$$u_i = \frac{\log(R_i) - \mu - \mathbf{x}_i'\boldsymbol{\beta}}{\sigma}, \tag{10}$$

$$v_i = \frac{\log(L_i) - \mu - \mathbf{x}_i'\boldsymbol{\beta}}{\sigma}. \tag{11}$$

Equation 9 shows that under the interval censoring each observation contributes two pieces of information to the likelihood, $S(L_i, \boldsymbol{\theta}_i)$ and $S(R_i, \boldsymbol{\theta}_i)$, which follows the same distributional function (Liu, 2012).

2.3.1 Log-logistic distribution

The results (see below) indicates, that the unemployment duration follows log-logistic distribution. AFT model for this distribution has the survival function:

$$S(t; \mathbf{x}, \boldsymbol{\beta}, \sigma) = \left[1 + \exp\left(\frac{\log(t) - \mathbf{x}'\boldsymbol{\beta} - \mu}{\sigma}\right)\right]^{-1}, \tag{12}$$

and characteristics of log-logistic distribution are:

$$E(X) = \frac{\alpha b}{\sin(b)}, \tag{13}$$

$$Var(X) = \alpha^2\left(2b/\sin(2b) - b^2/\sin^2(2b)\right), \tag{14}$$

$$Mode(X) = \alpha\left(\frac{\beta - 1}{\beta + 1}\right)^{1/\beta}, \tag{15}$$

$$F^{-1} = \alpha\left(\frac{p}{1-p}\right)^{1/\beta}, \tag{16}$$

where

$$\alpha = \exp(\mu)\exp(\mathbf{x}'\boldsymbol{\beta}), \tag{17}$$

$$\beta = \frac{1}{\sigma}, \tag{18}$$

$$b = \frac{\pi}{\beta} \tag{19}$$

(Liu, 2012).

2.4 Minimal adequate model

The idea of a minimal adequate model is based on the principle of parsimony called sometimes Occam´s razor. In regard to statistical modeling it states (among other things), that models should have as few parameters as possible.

The process starts with a maximal model, i.e. model containing all the possible explanatory variables with all the possible values of interest. Than, it is simplified step by step, first removing the explanatory variables one by one and then merging the values within the remaining variables.

Results in this paper were obtained by removing explanatory variables based on the p-values of log-likelihood ratio tests comparing the maximal model and the model without the variable of interest – the variable with the largest p-value was removed, if the p-value was greater than 0.05, otherwise it would be considered to significantly reduce the likelihood.

When there were no variables, which would meet the criteria, left, the categories of the remaining variables were merged in a similar way. As they were ordinal categories, the two values next to each others were always merged (Crawley, 2013).

2.5 Likelihood ratio test

In the process of building minimal adequate model from the maximal model it is important to make comparisons of models and choosing which explanatory variables should be dropped. In the current paper the process is based on the likelihood ratio test and is similar to the backward selection method known from regression.

In the likelihood ratio test the null hypothesis is:

$$\mathrm{H}\ : \boldsymbol{\theta} = \hat{\boldsymbol{\theta}}, \tag{20}$$

For all parameters in $\hat{\boldsymbol{\theta}}$, or:

$$\mathrm{H}\ : \theta = \hat{\theta}_m, \tag{21}$$

for a single component in θ, and the statistic:

$$\Lambda = 2\log\left(L(\hat{\boldsymbol{\theta}})\right) - 2\log\left(L(\boldsymbol{\theta})\right), \tag{22}$$

has asymptotically $\chi^2(m)$ distribution. $L(\boldsymbol{\theta})$ is the likelihood function for the model without one or more parameters and $L(\hat{\boldsymbol{\theta}})$ is the likelihood function for the model containing all parameters (Liu, 2012).

3 RESULTS

All calculations were done in MS Excel and R software, specifically package interval (Therneau, 2013), (Fay, 2013).

The first important thing to do is to identify plausible distribution. The nine distributions for the whole dataset (i.e. without explanatory variables) were estimated and the one with maximum likelihood is used further. There were two distributions with similar likelihoods – log-normal and log-likelihood, the later with a little greater likelihood. The same distribution was used by Jarošová et al. (2004). Distributions and corresponding log-likelihoods are in the Table A7 in the Annex.

Since all explanatory variables are ordinal or nominal variables, the second thing to do is to consider which value will create baseline distribution – $\mathbf{x} = \mathbf{0}$. The selected values are presented in the Table 1 as base values, it means that baseline distribution is for a single man in the age of 21–25 years with secondary education without graduation and living in a household of 2 persons in a municipality with size 1 000–9 999 inhabitants.

The maximal model is presented in the Table A8 in the Annex, with three variables without significant values – number of persons in household, marital status and municipality size. They were omitted from the model one by one as described in chapter 2.5. The order of drop-outs, log-likelihoods and p-values are in the Table A9 in the Annex. Model without insignificant variables is in the Table A10 in the Annex.

The third step here is to remove insignificant values by merging them. The process is described in the Table A11 in the Annex. Note that the final model has log-likelihood – 976.3 with 5 parameters, whereas the maximum model has log-likelihood – 961.9 but with 29 parameters, and the model without explanatory variables has log-likelihood – 990.8.

Minimal adequate model is in the Table 2. Other thing being equal unemployment duration for women is longer than for men by 17.1%, for the youngest category (16–20 years) is shorter than for the rest of unemployed by 28.5% and is shorter by 32.8% for unemployed with university education in comparison to the rest.

Table 2 Minimal adequate model

Variable	Code	Parameter estimate bi	S.E.	p-value	exp(bi)
Intercept		2.220	0.0506	0.000	–
Pohl	2	0.158	0.0645	0.014	1.171
VekSk	1	–0.336	0.1087	0.002	0.715
ISCED	5	–0.398	0.0974	0.000	0.672
Log(scale)		–0.799	0.0378	0.000	–

Source: CZSO, own construction

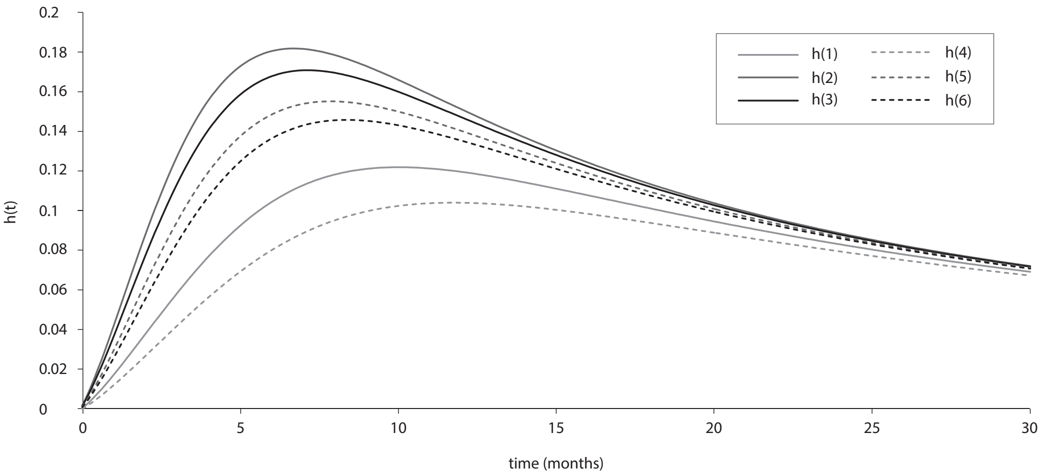
Table 3 Effects of combinations on time scale

N.	Sex	Age group	ISCED	exp(x´β)	E(X)	Var(X)	Median	x0.9	Mode	Obs.
1	Male	> 20	2–4	1	13.174	598.443	9.207	24.736	5.955	245
2	Male	> 20	5	0.672	8.848	269.975	6.184	16.614	3.996	29
3	Male	16–20	2–4	0.715	9.414	305.617	6.580	17.677	4.256	34
4	Female	> 20	2–4	1.171	15.429	820.842	10.783	28.970	6.974	280
5	Female	> 20	5	0.787	10.363	370.307	7.243	19.458	4.684	54
6	Female	16–20	2–4	0.837	11.026	419.193	7.706	20.703	4.984	31

Source: CZSO, own construction

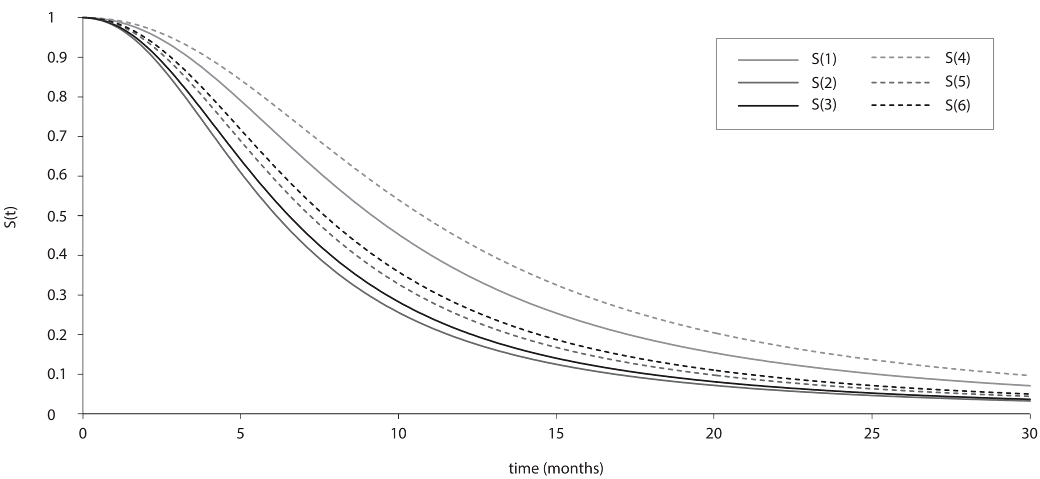
The baseline distribution is now for men older than 20 years without university education. For baseline distribution parameters and characteristics are α = 9.207, β = 2.223, b = 1.413, E(X) = 13.174, Var(X) = 598.443, median = 9.207, $x_{0.9}$ = 24.736 and mode = 5.955. Characteristics for all 6 possible combinations are in the Table 3 – note that 2 combinations (for men and for women) of university education and age group 16 – 20 years are impossible. Figures 1 and 2 contain hazard functions and survival functions of all possible combinations, respectively.

Figure 1 Hazard functions for all six possible combinations



Source: CZSO, own calculations

Figure 2 Survival functions for all six possible combinations



Source: CZSO, own calculations

4 DISCUSSION

4.1 Data limitations

At the present paper the status of economic activity is checked at the entry into the survey and at the exit. It is much easier to find the participants who found a job this way, but it means that there are possible omitted cases – firstly the situation in which a participant finds a job in between and then loses it, secondly the situation in which participants lose jobs and then find and lastly the situation when they find a job, lose it and find it again. These cases are possible but not very likely, so their omission should not change the overall results.

The more likely and thus problematic case is omitting of cases of participants, who were not in the labor force and then found a job. This is necessary because for these cases it is impossible to calculate the duration of their unemployment in the sense used throughout the paper.

Reader should still keep in mind that unemployment duration is calculated only for those, who found a job within a five quarter period. It is not unemployment duration at some specific time point and not an unemployment duration of those who did not find a job, neither.

4.2 Results in the context of previous research

The results presented here are in line with the results presented in Čabla (2015), where unemployment duration was different for variables sex and ISCED, but not for age groups without the youngest group 16–20 years. These results were obtained by several models with only one explanatory variable in each, whereas here I confirm those results using multivariable model.

The age group 16–20 years is in different situation than the rest of unemployed – they have usually secondary education with or without graduation (ISCED = 3 or 4) and in my hypothesis are looking for a job soon after the end of their education in the age of. The end of tertiary education is usually more dispersed and people leaving universities do not form a specific age group.

It presents a shift from the crisis situation (year 2010), in which marital status and age played significant role (Čabla, 2012). But note that the crisis results were obtained from the data set containing those who did not found a job either, so the results are not directly comparable.

The use of log-logistic distribution for modeling unemployment duration is not usual in last years but the distribution was used in the further past by Jarošová et al. (2004). The second distribution which fits the data is log-normal.

4.3 Further research

The presented results are just a part of a research of unemployment duration. They describe the post-crisis situation on the limited dataset of those who found a job. The focus should now move on the direct comparison of pre-crisis, crisis and post-crisis situation. It also would be useful to make similar research on the dataset containing all the unemployed at the beginning and research at specific time points to compare the results from these.

CONCLUSION

An unemployment is one of the leading economic problems and the paper contributes to our understanding of the problem. The paper identifies and quantifies the differences in the unemployment duration in different strata in the post-crisis Czech Republic via building a minimal adequate model.

The unemployment duration is described as a survival function $S(t)$ and hazard function $h(t)$ of log-logistic distribution as a part of accelerated failure time model with explaining variables. The estimated expected values, variances, medians, modes and 90th percentiles are provided for all subgroups.

The variables in the maximal model are sex, marital status, age, education municipality size and number of persons in a household and the model contains 29 parameters. The model is reduced in a backward selection manner with the use of likelihood ratio test – first the explanatory variables are reduced and then the categories of remaining variables are merged. The minimal adequate model contains five parameters – two of the log-logistic distribution and three describing the differences between men and women, the youngest and the rest and those with university education and the less educated.

The duration of unemployment is longer for women by 17.1%, shorter for the youngest category by 28.5% and for people with university education by 32.8%. The findings are limited to the group of those who found a job during the selected period, i.e. in the last quarter of year 2013 and year 2014. This is in line with previous findings but there is a need to make more direct comparison to the findings from previous time periods.

ACKNOWLEDGMENT

The paper was processed with contribution of long term institutional support of research activities by Faculty of Informatics and Statistics, University of Economics, Prague. The support of the grant scheme IG410045 by the University of Economics IGA is gladly acknowledged.

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ANNEX

Table A1 Coding and observations of Number of persons in the households

Code	Observations
1	63
2	181
3	179
4	183
5	49
6	13
7	4
8	1

Source: CZSO, own construction

Table A2 Coding and observations of Sex

Code	Meaning	Observations
1	Male	308
2	Female	365

Source: CZSO, own construction

Table A3 Coding and observations of Marital Status

Code	Meaning	Observations
1	Single	319
2	Married	252
3	Widowed	13
4	Divorced	89

Source: CZSO, own construction

Table A4 Coding observations observations of Age group

Code	Meaning	Observations
1	Age 16–20	65
2	21–25	116
3	26–30	81
4	31–35	65
5	36–40	109
6	41–45	61
7	46–50	72
8	51–55	58
9	56–60	39
10	Age > 60	7

Source: CZSO, own construction

Table A5 Coding and observations of ISCED

Code	Meaning	Oservations
2	Primary education	54
3	Secondary without graduation	302
4	Secondary with graduation	234
5	Terciary	83

Source: CZSO, own construction

Table A6 Coding and observations of Municipality Size

Code	Meaning	Observations
1	Population < 1 000	133
2	1 000–9 999	219
3	10 000–49 999	170
4	50 000–99 999	71
5	Population > 100 000	80

Source: CZSO, own construction

Table A7 Log-likelihoods of selected distributions for whole population

Distribution	Log-likelihood
Loglogistic	– 990.8
lognormal	– 991.2
Weibull	– 1 040.8
exponential	– 1 055
t	– 1 154.9
rayleigh	– 1 197.7
logistic	– 1 197.9
gaussian	– 1 262.7

Source: CZSO, own construction

Table A8 Maximal model (statistically significant parameters are bold)

Variable	Code	Parameter estimate	S.E.	p-value
Intercept		**2.46876**	**0.1098**	**0.000**
PocOD	1	–0.12615	0.1296	0.330
	3	0.12841	0.0893	0.150
	4	0.15176	0.0952	0.111
	5	0.16093	0.1417	0.256
	6	0.29967	0.2510	0.233
	7	–0.13028	0.4008	0.745
	8	0.58231	0.6471	0.368
Pohl	**2**	**0.18639**	**0.0679**	**0.006**
RodStav	2	–0.18822	0.1109	0.090
	3	–0.43506	0.2599	0.094
	4	–0.10593	0.1303	0.416
VekSk	**1**	**–0.41861**	**0.1310**	**0.001**
	3	–0.08182	0.1206	0.497
	4	0.00721	0.1364	0.958
	5	0.09595	0.1345	0.476
	6	–0.05861	0.1623	0.718
	7	0.15552	0.1599	0.332
	8	**0.36252**	**0.1697**	**0.033**
	9	0.26462	0.1951	0.170
	10	–0.23308	0.3661	0.524
ISCED	2	0.12389	0.1227	0.313
	4	–0.07346	0.0752	0.328
	5	**–0.41784**	**0.1090**	**0.000**
MuniSize	1	0.03356	0.0923	0.716
	3	–0.00589	0.0866	0.946
	4	–0.02842	0.1130	0.801
	5	–0.17781	0.1113	0.110
Log(scale)		**–0.82385**	**0.0379**	**0.000**

Source: CZSO, own construction

Table A9 Dropouts and log-likelihood

Dropped variable	Log-likelihood	p-value
Maximal model	–961.9	NA
Municipality Size	–963.7	0.482
Number of Persons in a Household	–968.2	0.318
Marital Status	–969.5	0.363

Source: CZSO, own construction

Table A10 Model without insignificant variables (statistically significant parameters are bold)

Variable	Code	Parameter estimate	S.E.	p-value
Intercept		**2.27551**	**0.0939**	**0.000**
Pohl	**2**	**0.17609**	**0.0658**	**0.007**
VekSk	**1**	**–0.33995**	**0.1292**	**0.009**
	3	–0.09822	0.1181	0.406
	4	–0.03978	0.1262	0.753
	5	–0.01608	0.1131	0.887
	6	–0.17116	0.1360	0.208
	7	–0.00102	0.1234	0.993
	8	**0.17244**	**0.1338**	**0.198**
	9	0.03999	0.1595	0.802
	10	–0.60855	0.3373	0.071
ISCED	2	0.08661	0.1224	0.479
	4	–0.11623	0.0741	0.117
	5	**–0.44643**	**0.1076**	**0.000**
Log(scale)		**–0.81103**	**0.0379**	**0.000**

Source: CZSO, own construction

Table A11 Merging variables

Step	Variable	Values merged	Log-likelihood	p-value
Start	NA	NA	–969.5	NA
1	ISCED	2+3	–969.8	0.401
2	Age Group	4+5	–969.8	0.471
3		3+4+5	–970.0	0.513
4		2+3+4+5	–970.2	0.558
5		8+9	–970.4	0.589
6		7+8+9	–970.9	0.593
7		2+3+4+5+6	–971.6	0.559
8		2–9	–972.9	0.459
9		2–10	–974.6	0.332
10	ISCED	2–4	–976.3	0.228

Source: CZSO, own construction

Establishment of the Quality Documentation System in the Croatian Bureau of Statistics

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Abstract

The main goal of the Croatian Bureau of Statistics (hereinafter: CBS) in recent years was to establish a widely accepted general framework for quality assessment and quality improvement of CBS's statistical processes and products. The CBS adopted the Total Quality Management (TQM) approach as the general model for quality management, quality assessment and quality improvement.

The CBS also established a quality documentation system for statistical products and processes. This database of quality information became a key tool for quality assessment, quality documentation and quality reporting for CBS surveys. The database contains an exhaustive list of quality information, which is based on two widely accepted ESS structures, ESMS and ESQRS, divided in two parts: numerical information (quality indicators) and descriptive (textual) information. The CBS has also decided to implement Generic Statistical Business Process Model (GSBPM) for documenting statistical processes, because it exhaustively describes and defines a set of business processes needed to produce official statistics.

Keywords	***JEL code***
Quality Reporting, Quality Documentation, Quality Database	*L15*

INTRODUCTION

The Croatian Bureau of Statistics (hereinafter: CBS) has a long tradition of producing good quality data. Actually, the whole Statistical System of the Republic of Croatia is oriented towards production of relevant statistics by following quality requirements prescribed by the Regulation on European statistics.

CBS's activities regarding quality improvement of statistical processes and products were focused on the development of all their quality aspects. CBS's quality management is the basic prerequisite for the stable development of statistics while at the same time it strengthens the reputation of the entire national and European statistical system.

Since 2010, when a brief review of the implementation of the European Statistics Code of Practice was carried out in Croatia (called Light Peer Review[2]), the number of new quality reports for CBS's statistical outputs

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2 PeerReview is an control instrument of the national statistical system applied in the European statistical system. This instrument assesses the application of the Code of Practice of European statistics. The purpose of the Code of practice, i.e. its application, is to increase confidence in the independence, integrity and accountability of the national statistical authorities and Eurostat and the credibility and quality of the statistics they produce and disseminate. Furthermore, the purpose of the Code is to promote the application of best international statistical principles, methods and practices of all producers of European statistics.

increased significantly, as well as the number of handbooks and methodologies for assessing and monitoring quality. All these quality reports, handbooks and methodologies establish a quality documentation system.

What the CBS was missing all the time was a systematic approach to quality management, especially in preparation and implementation of quality management models. The CBS has therefore implemented a project on establishing a system for the quality documentation of statistical processes and statistical products, which includes the preparation and establishment of a model that will enable quality management in the CBS, in line with the European standards.

CBS's quality improvement activities are focused on all quality aspects of statistical processes and products that are being continuously developed and improved in line with ESS recommendations.

Availability of high-quality and timely statistical information is necessary for developing and monitoring of specific policies, particularly in relation to their impact and fulfilment of their objectives. After joining the European Union, besides national development goals, the Republic of Croatia directed its efforts to the achievement of common strategic objectives of the EU, which represents an additional challenge in terms of quality and structural characteristics of statistical data.

As a member of the European statistical system, the CBS is committed to provide the optimal level of quality of statistical processes and products, to use statistical methods and processes in accordance with internationally recognised principles and standards, and to continuously conduct analyses with the aim to improve the quality of those processes and products. During the adoption of the European Statistics Code of Practice, the CBS (as well as the other national statistical institutes of EU Member States) directed all its efforts to comply with the principles and standards necessary for the production and distribution of quality statistical products.

The European Statistical System Committee (ESSC) adopted the European Statistics Code of Practice and published its directions on the independence, integrity and accountability of the national statistical offices and institutions of the EU in the Commission Recommendation (2005) in February 2005. The European Statistics Code of Practice is based on 15 principles covering the institutional environment, statistical production processes and statistical results. The objective within the ESS system is not only to ensure that the data produced is statistically relevant, timely and accurate, but also to ensure that they are in accordance with the principles of professional independence, impartiality and objectivity. A set of indicators of good practice for each of the 15 principles provides a reference for measuring and implementing the Code. The ESSC adopted the revised Code on 28 September 2011. Shortly after, the CBS adopted the European Statistics Code of Practice, which is fully in line with the UN Fundamental Principles of Official Statistics, as well as with the national and European legislation. In accordance with the Code of Practice of European Statistics, the goal of CBS is to strengthen confidence in the independence, integrity, accountability, credibility and quality of the statistics that are produced and disseminated. The CBS seeks to implement the best international statistical principles, methods and practices to ensure the production and dissemination of representative, relevant and internationally comparable statistical data. Therefore, it is of crucial importance to monitor the quality of data and to quality control all statistical processes that CBS is dealing with. Data quality is a multi-dimensional concept that applies not only to the statistical accuracy of data but also to the comparability, relevance, punctuality and timeliness, availability and clarity of information.

The CBS thus established a quality documentation system for statistical products and processes. A database of quality information was established and it became a key tool for quality assessment, quality documentation and quality reporting for CBS's surveys. The database contains an exhaustive list of quality information based on two widely accepted ESS structures – ESMS and ESQRS – divided in two parts: numerical information (quality indicators which represent the most demanding part of the list of quality information which is gathered through the survey process) and descriptive (textual) information which refers directly to the survey quality assessment.

For documenting statistical processes the CBS has also decided to implement Generic Statistical Business Process Model (GSBPM) because it exhaustively describes and defines a set of business processes needed to produce official statistics.

Dimensioning the quality management documentation system based on our organizational needs is essential for a functional quality management system. Moreover, properly structured documentation will make our operations much easier, while incorrect documentation will bring us nothing but trouble.

Regarding establishment of the quality management system, the CBS had two main goals: to establish a quality management documentation system and to train CBS's staff in activities regarding quality management. The CBS initially started with the preparation and collection of documentation on the quality control of all statistical processes and products in 2013. These three main activities were defined afterwards in order to establish strong quality management documentation system in the CBS:

- Activity 1: Establishing quality management documentation system,
- Activity 2: Selecting six pilot surveys for testing quality and establishing links to Croatian metadata repository (CROMETA),
- Activity 3: Training a number of CBS staff in preparing quality reports.

1 THE BEST AVALIABLE MODEL FOR QUALITY MANAGEMENT FRAMEWORK CHOSEN AND DOCUMENTED

Having studied different models and experiences of EU Member States used for quality monitoring of statistical processes and statistical products, the CBS decided to use Total Quality Management – TQM. This model offers a high degree of flexibility, while in adjoining countries (Austria, Slovenia) it has already proven its functionality and efficiency.

In order to establish the highest quality level, the CBS set up a management model in accordance with the Total Quality Management – TQM principles. For each of these general aims, specific actions are foreseen, while plans for their implementation are described in a strategic document. When the first version of the document was finished, it was given over to broader "public discussion" to get useful comments and suggestions for further development. This comprehensive document about the TQM deals with quality throughout the entire CBS organisational structure.

Principles and main goals of CBS according to TQM are as follows:

1. Statistical processes and products of good quality,
2. Satisfied statistical data users,
3. Reduction of the response burden of respondents (including establishment of good communication with the respondents),
4. Effectiveness of statistical processes (internal productivity),
5. Vocational guidance of staff (education, motivation and satisfaction).

The first form of the TQM is already developed in the CBS, but it is still part of a development process, with the aim for it to be continuously improved. Specific projects and measures for achieving the goal are defined for every TQM section. The CBS uses the standard documentation prepared in accordance with the Eurostat's recommendations. Detailed documentation is prepared for internal purposes in the Croatian language, while the information provided to the users is available in Croatian and English The information on concepts, definitions, and methods used, as well as on the quality level of statistical data (meta information) is provided in standardised format.

By adopting these documents based on the multidimensional concept compliant with EU standards (such as relevance, accuracy, comparability, timeliness and punctuality, accessibility and clarity, and coherence) the CBS created a basic framework of good quality for ongoing internal and external evaluation of statistical processes and products. In order to introduce systematic quality management of statistics, the CBS, also established an organisational unit for general methodology and quality that would take care of quality management in a centralised and systematic way.

The TQM requires continuous improvement that consists of project planning activities which need to be defined, implemented and finally tested. Dealing with quality improvement in the CBS is an ongoing challenge in which all employees are included.

2 DATA QUALITY ASSESSMENT METHODS AND TOOLS DEFINED

CBS's experts have developed different data quality assessment methods and tools in last two years. They are the most important part in establishing the quality documentation system in the CBS. Some of the most important ones are:

a) *Glossary of the quality terms.* Commonly agreed and accepted terminology is one of the basic conditions for further development. Therefore, the CBS created a glossary of the terms from the quality area. Approximately 300 terms are included in the glossary. The Croatian translation is provided for each English term, together with a short description of the term (in both Croatian and English).
b) *Database of quality information (DBQI)*, which became a key tool for quality assessment, quality documentation and quality reporting for CBS's surveys. The database content is based on an exhaustive list of quality information, which is further based on two widely accepted ESS structures, ESMS and ESQRS.
c) *Methodological handbook on quality indicators.* Quality indicators are numerical values which indicate the level of quality attained in statistical surveys. From the methodological point of view, quality indicators represent the most demanding part of the list of quality information gathered through the survey process.

Quality indicators are used in the quality reports, especially by management. Sometimes a quality indicator will show that something is wrong and that there is a need for action. An example can be steadily decreasing response rates of some surveys. Management discussions on the development of performance and quality indicators must be constructive and actively consider and suggest improvement possibilities.

Some more thorough explanations and guidelines were needed in order to ensure a standardized and harmonized procedure of calculating indicators in all surveys. The handbook for each of the quality indicators provides the following sections:

- Definition of the indicator,
- Calculation procedure,
- Example(s).

The main goal of the document is to ensure a more standardized methodology of calculation of quality indicators in CBS's surveys. When the handbook was finalised, the CBS organised a workshop with the survey managers and described the content and practical usage of the handbook.

d) *Standard list of response statuses.* Correct calculation of some of the quality indicators (e.g. response rate, over-coverage rate) largely depends on the correct response statuses of each observational unit. With the "response status" we here refer to information which clearly indicates what the status of the unit is after the collection phase. Roughly three main groups could be defined: Responding units; Non-responding units; Ineligible units. These main groups can then be further divided according to different reasons. To enable standardized calculation of the above mentioned quality indicators the CBS needed a standardized list of response statuses which should be used in all CBS's surveys and could become a basis for standardized procedure of the calculation of quality indicators. Two separate lists were drafted: one for business surveys and one for social surveys.
e) *Standard template for quality report.* One of the functionalities of the database of quality information is easy and user-friendly creation of CBS's quality reports that should be publicly available

on our website. The National Statistical Institutes (NSIs) produce quality reports required by several international organisations and deliver them together with the data. Many NSIs produce different types of standardised documentation which are user or producer oriented.. In order to avoid such duplication of information in different quality reports, the CBS created a standard template, which includes a list of quality information requested both by users and producers. The template comprises an exhaustive list of quality information. This list is now divided in two parts: information which is part of the report and information with lower priority (the inclusion of which was decided upon later, in a testing phase). The level of detail in these reports is an issue. The extent and complexity of the reports tends to increase over time, and we should realise that the target group in practice are mostly demanding users. For example, producers will always need more comprehensive documentation linked to the standard report. On the other hand, users need simplified information linked to or directly integrated in the text following the release of statistics. The standard template for quality report is continuously being developed by taking into account comments and suggestions for improvements from survey managers of the pilot surveys.

3 SELECTING SIX SURVEYS FOR TESTING QUALITY AND ESTABLISHING LINKS TO NATIONAL METADATA REPOSITORY CROMETA

To enable applicability and usability of the tools developed through the project, all the developments should be carried out with a strong connection to the survey practice. For this purpose the CBS selected six surveys which would serve as pilot surveys. The six chosen pilot surveys are:

- Survey on Income and Living Conditions (EU-SILC),
- Monthly Survey on Industrial Production,
- Structural Business Statistics of Enterprises (SBS),
- Annual Survey on Information and Communication Technology Usage in Enterprises (ICT-ENTR),
- Final Energy Consumption in Households,
- Services Producer Price Indices for Cleaning Activities.

The list of pilot surveys can be divided into two groups:

1. The first four surveys are existing surveys which have been carried out in CBS for a long time. Testing in these surveys is already finalised and the survey managers have gathered the required information which was later inserted into the database. Several meetings with the survey managers were organised in order to clarify unclear or ambiguous concepts and definitions.
2. The last two surveys will be developed within other components of the project. These surveys will be included in the testing process in the next phase of project implementation.

4 ESTABLISHMENT OF THE QUALITY DOCUMENTATION SYSTEM

When people think of quality management system documentation they usually envision loads of documents, and unnecessary and bureaucratic procedures. This is because companies often go overboard when documenting their Quality Management Systems (hereinafter QMS). However, this need not be the case. The QMS documentation can consist of different types of documents. It usually includes documents such as quality policy, quality manual, procedures, work instructions, quality plans, and records.

The purpose and the benefits of QMS documentation are manifold. The QMS provides a clear framework of the operations in an organization, allowing consistency of processes and better understanding of the QMS, while at the same time providing evidence for achievement of objectives and goals. When designing QMS documentation, we should all focus on efficiency and create processes and documents that are applicable in your organization.

CBS's experts have thus established two parts of quality documentation system. The first one is the already mentioned database of quality information and the second is strictly used for documenting statistical processes.

4.1 Database of quality information (DBQI)

DBQI became a key tool for quality assessment, quality documentation and quality reporting for CBS' surveys. Database content is based on an exhaustive list of quality information, which is further based on two widely accepted ESS structures, ESMS and ESQRS, divided in two parts: numerical information (meaning quality indicators which represent the most demanding part of the list of quality information which are gathered through the survey process) and descriptive (textual) information which refers directly to the survey quality assessment.

All the information in the database can roughly be divided in two parts:

1) Numerical information, also called quality indicators. The whole list of quality indicators is divided in two parts: key indicators, which should be mandatory and calculated in all the surveys for which the quality assessment will be performed, and supportive indicators, which will be calculated if the survey manager considers them important for the quality assessment of a particular survey.
2) Descriptive (textual) information. This list can also be divided in two parts: information not directly connected to the quality assessment but aimed at describing the important characteristics of the survey, and information which refers directly to the survey quality assessment.

To achieve the usefulness of this tool, the database itself had to be upgraded with a user-friendly application that enables easy inserting of information and management of inserted information. The first phase of development was devoted to the physical creation of the database and development of this user-friendly tool. The second phase is then devoted to the development of the management tool. At the beginning of the second phase we defined requirements for the output functionalities. These functionalities can be summarized as follows:

- Survey manager authorization. Each survey manager should have the right to edit only specific surveys and view data from any survey. Survey manager must be checked before they start working with the application. This functionality is implemented by using Croatian metadata repository – CROMETA – web service.
- Formatting of quality indicators into a readable (formatted) form. Application should enable creation of formatted tables from indicator values. This functionality is especially important for the sub-annual surveys. In these cases the table should summarize the values for the whole year.
- Filling out the template for standard quality report. A quality report provides information on the main quality characteristics of a product for its users. Quality reports are normally based on quality indicators describing these characteristics and are important for both the producers and the management. The requirements of users and producers are different but a standard structure is preferable, so the application enables automatic transfer from the DBQI into the template for Standard Quality Report. Textual information from the database of quality information should be transferred unchanged, while the indicators should first be formatted into tables. One of the functionalities of the database of quality information is also easy and user-friendly creation of CBS's quality reports, which should be publicly available on our website.
- Development of the basic analytical tool for comparative analyses of quality indicators. This tool should enable comparison for a selected reference period and for a selected indicator between all surveys. The comparison should be performed only on the level of the whole survey (no domains included). The tool should provide a list of indicator values for all the surveys for which the certain indicator is available on demand.
- Creating XML for the National Reference Metadata Editor (NRME) – export from one system to another. This application should enable automatic transfer from the DBQI into NRME editor as well as vice versa, from NRME editor into DBQI. Textual information from the database of quality information should be transferred unchanged, while the indicators should first be formatted and then transferred into the NRME editor.

- Supplementation of the information in the database (Documentation). The first part of the database, which contains textual information, should be supplemented with the information derived from documenting the statistical process. The list of items for this part is already prepared and consists of 36 sub-processes while each sub-process is further divided into 4 standard elements.
- Integration with metadata repository "CROMETA". Static lists added from CROMETA should be replaced with dynamic lists retrieved from CROMETA via web services. If any change appears in CROMETA it is automatically updated in the DBQI.
- Development of the advanced analytical tool for comparative analyses of quality indicators. The application should enable two types of comparative analyses for a particular quality indicator:

1. Analyses through time. When a user selects a starting and ending date as a reference period, the application provides a time series of a selected quality indicator. The series are presented in the form of tables and line charts.
2. Analyses between domains. The application should enable two different domain comparisons. The first one takes into consideration the specific indicator values and specific reference period between the indicator values for a chosen domain in a specific survey (e.g. response rate for different regions in LFS in 1st quarter 2012). The second one enables a comparison between the different (selected) surveys. The values are presented in tabular and bar chart form.

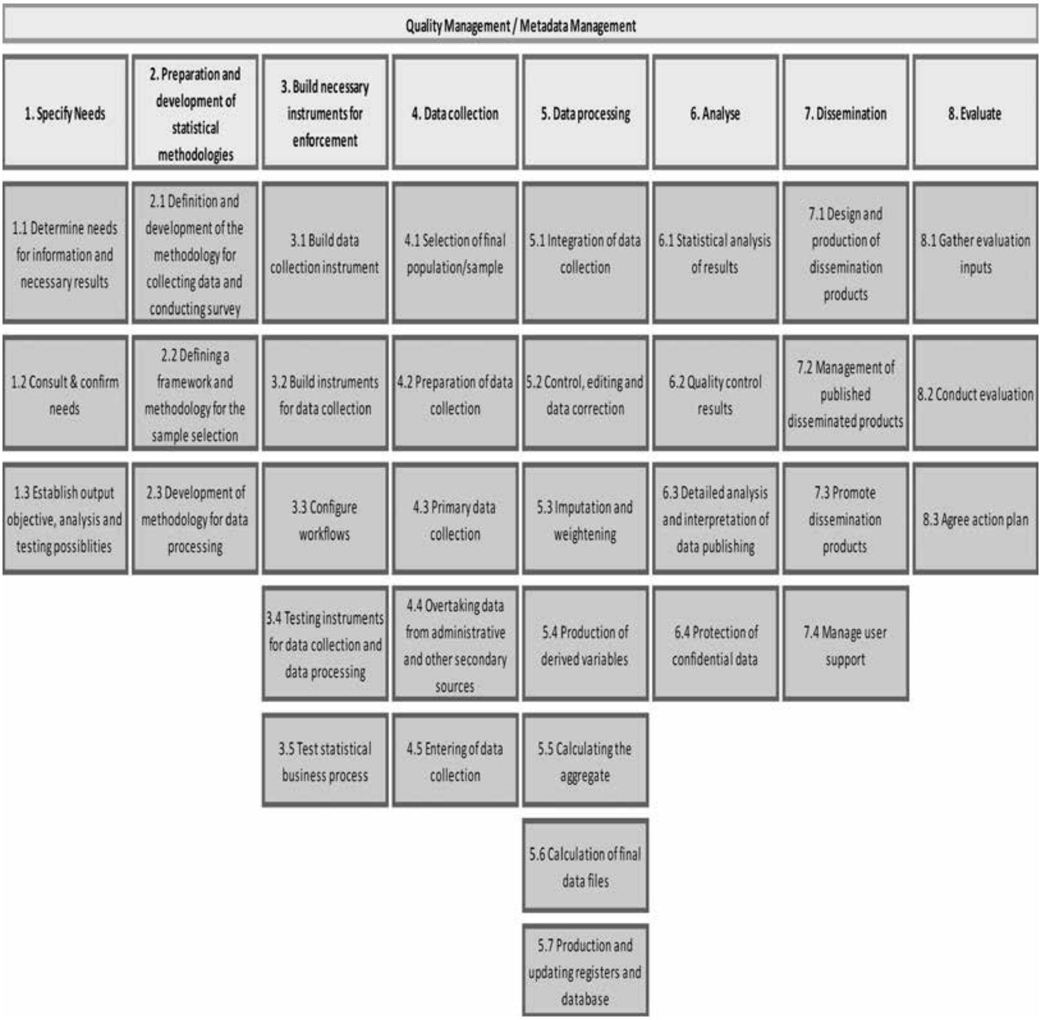
4.2 Documenting processes according to GSBPM model

Because the CBS is process orientated, all CBS employees are aware that we can obtain better quality results and better cost-efficiency only with transparent statistical processes and clearly documented procedures. Having in mind all statistical quality aspects, the CBS has decided to implement Generic Statistical Business Process Model (GSBPM), as it exhaustively describes and defines a set of business processes needed to produce official statistics. It provides a standard framework and harmonised terminology to help statistical organisations modernise their statistical production processes, and share their methods and components. The GSBPM can also be used for integrating data and metadata standards, as a template for process documentation, for harmonizing statistical computing infrastructures, and to provide a framework for process quality assessment and improvement. Based on the GSBPM structure the CBS has carried out analysis of how this model can be implemented in practice in the Croatian statistical system. On the basis of this analysis, we prepared a slightly adjusted CBS process model (Figure 1). The adjusted model was then used as a basis for the creation of a standard template for preparation of survey documentation. This template is now used for describing and documenting every statistical survey in a standardised and harmonised way. In this way, the GSBPM is adjusted to the needs of the Croatian statistical system and designed as a model independent of the data source, so that it can be used for describing and evaluating the quality of the processes based upon surveys, censuses, administrative records and other non-statistical or combined data sources. Such a business model, combined with an organizational structure for coordinating quality work, constitutes the necessary infrastructure for systematic quality work in a statistical institution.

The statistical business process usually involves the collection and processing of "raw" data for producing statistical results. The GSBPM is applicable in cases where existing data is revised or time series are re-calculated. In such cases, the input is taken as previously published statistical data which is then processed and analysed to obtain revised results (outputs). In such cases there is a possibility to skip several sub-processes and some work stages.

Besides the fact that the model is applicable to processes that provide statistical results, the GSBPM can also be applied to the development and maintenance of statistical registers in which the input is similar to the statistical production and the results are usually frames of data set and then used as input for other processes.

Figure 1 GSBPM model adjusted to the needs of the Croatian statistical system



Source: Croatian Bureau of Statistics

The GSBPM is not designed as a strictly defined framework in which all steps must be applied in the same order, but as a model that identifies steps in a statistical business processes and acknowledges the interdependencies between them. Although the presentation of the model shows the logical sequence of work phases in most statistical business process, model elements can appear in a different order. Therefore the GSBPM is a simple and widely applicable model.

The model includes the following activities:

– Quality management – This process includes mechanisms for evaluation and quality control, and recognizes the importance of evaluation and feedback during the statistical business processes.

– Metadata management – Metadata is created and handled within each phase and there is a strong requirement to ensure that the appropriate metadata retains thelinks with information during the application of GSBPM.
– Statistical framework management – It includes the development of standards, such as methodologies, concepts and classifications applicable through many processes.
– Statistical programme management – It includes systematic monitoring, controlling of resulting information requirements for these liabilities, and changing of data sources across all statistical areas. This can result in the definition of new statistical business process or a redesign of existing ones.
– Knowledge management – It ensures repeatability of statistical processes, mainly by maintaining the documentation of processes.
– Data management – This includes process-independent aspects of the process, such as general data security, custody and ownership of data.
– Process data management – It includes management of data and metadata derived from all parts of the statistical business processes and providing information about them.
– Provider management – This includes managing the burdens that are transferred from process to process, as well as topics such as profiling and data management for the contact (closely related to the statistical business processes that maintain registers).
– Customer management – It includes general marketing activities, promoting statistical literacy and treatment of non-specific customer feedback.

To estimate which level of data quality has been achieved by a statistical survey, it is necessary to study the information and procedures applied in detail, as well as to look at the input and output of the implemented statistical process. It includes an analysis of the methodology and implemented statistical production process (how the data were collected, statistically treated, processed and analysed). It also includes a comparison of results achieved towards the relevant standards with alternative sources of information, prior knowledge or logical expectations. Of course, all these quality aspects are of high importance.

CONCLUSION AND FUTURE DEVELOPMENTS

As it was described in this paper in detail, the key outcomes of the activities carried out in this period of quality management implementation in the CBS were:

- Creation of the TQM strategic document,
- Creation of the glossary of the quality terms,
- First version of the database of quality information developed and tested,
- Creation of the methodological handbook on quality indicators,
- Creation of the standard list of response statuses,
- Survey managers of pilot surveys educated about the main concepts in the field of quality assessment and trained to collect the required quality information,
- Seminar on Quality Management and Quality Assessment Frameworks carried out,
- Workshop on Quality assessment Methods and Tools carried out.

From the previous sections, it is clear that good progress has been made for each of these minimum expected outputs of the quality documentation system implementation. There is no reason to expect that this process will not continue to deliver and possibly exceed in some areas, as has already happened with CBS's attendance at the seminar and workshops, which was one of the activities in implementing the quality management system. Although not specified above as an output, the quality work will also provide a quality database containing a number of agreed quality indicators for the CBS. For all outputs full documentation and an active approach to training of the CBS in the quality procedures developed in the project will be made available. It is also recognised that including practical examples in the training materials about quality processes would be very beneficial to CBS's staff. A clear priority in development will be to ensure sustainability. It is important that the resource requirements of the new quality work are put in place in this project to match the resources CBS is able to devote to this work.

The CBS will often need to prepare a range of reports and data to support the sustainability of the quality of work. Clear examples of this are the quality indicators that need to be calculated before being added to the quality database. This will place an overhead of costs on the CBS staff, although this overhead will be the highest in early days of preparing these indicators and will afterwards start gradually reducing. It will be important that the CBS ensures that their experts meet this overhead cost in populating the quality dataset. If this requirement is not met, the very quality of the indicators themselves will be threatened. An important action by the CBS management in ensuring the sustainability of work quality is to ensure that the outputs produced by the CBS staff are actively studied by management and have some impact on management decisions concerning the organisation and allocation of CBS's resources. So, the outputs from the work in this project on quality will help the management of the CBS in their strategic and operational policy work to identify and address priority quality issues across the statistical activities of the CBS.

In terms of progress in quality area, key outcomes in the last months include focus on the development of the Quality Database and its testing through pilot surveys. As it has been noted above, this progress has led to pressure for more development work – especially in terms of outputs from the system. As all quality documentation components are well received by the CBS, they will continue to be developed throughout time and at the focus can lie with the Quality Database, the work on TQM strategy, the glossary of quality terms or the methodological handbook. During the remaining period of the project the focus will be on drawing the activities to a close and to the full satisfaction of the CBS.

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2015 IFCS Conference

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From 6th to 8th July 2015, a conference of the International Federation of Classification Societies, see (IFCS), took place in Bologna. This assembly of statisticians focusing on data analysis methods for classification, including cluster analysis, was organized on the occasion of the 30th anniversary of the IFCS foundation, see (Bock).

The IFCS conferences are usually held once in every two to three years. Although activities of the IFCS were not significant in recent years, the 2015 IFCS conference proved that classification is an important topic bringing together significant statistical personalities from around the world.

The programme included invited lectures, special sessions, sessions of oral contributions of other participants, and a poster session. Five parallel sessions were held. The conference was launched at the Department of Physics and Astronomy, the University of Bologna, and then the Department of Statistical Sciences was the venue.

Part of the introductory session was devoted to the 30th anniversary of the IFCS. At the opening, among others, Professor Maurizio Vichi, a president of the IFCS, spoke. By the means of a videoconference, Professor A. Gordon, who was a president of the IFCS in 1994 and 1995, also participated.

Participants heard many interesting contributions, abstracts of which have been published, see (IFCS 2015). Interest in the lectures and contributions was considerable, lecture halls were crowded. Participants could spend their free time between blocks of lectures in arcades of the ancient university town, where they met rejoicing university graduates. A pleasant atmosphere helped overcome very high temperatures during the conference in this part of Italy.

Great attendance at the conference of older and younger statisticians, especially when there is a large amount of conferences, indicates that the existence of the IFCS and its activities are important elements in the scientific community. The next IFCS conference will be held in Tokyo in 2017.

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Recent Publications and Events

New publications of the Czech Statistical Office

Food Consumption in 2014. Prague: CZSO, 2015.
KUČERA, L. *Hodnocení výkonnosti ekonomiky České republiky v širším kontextu.* Prague: CZSO, 2015.
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Other Selected Publications

BANSAK, C., SIMPSON, N. B., ZAVODNY, M. *The Economics of Imigration.* London, NY: Routledge, 2015.
EASTERLING, R. G. *Fundamentals of Statistical Experimental Design and Analysis.* New Mexico, USA: Wiley, 2015.
FIŠEROVÁ, E. *Lineární statistické modely.* Olomouc: UP, 2015.
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JARUŠOVÁ, D. *Pravděpodobnost a matematická statistika.* Prague: ČVUT, 2015.
PILATI, M., SHEIKH, H., SPEROTTI, F., TILLY, CH. *How Global Migration Changes the Workforce Diversity Equation.* Cambridge Scholars, 2015.

Conferences

The European Conference on Quality in Official Statistics (Q2016) will take place **in Madrid, Spain, from 1st to 3rd June 2016**. The conference is organized by the National Statistical Institute of Spain (INE) and Eurostat and aims to cover relevant and innovative topics on quality ranging from the challenges and the new paradigm of quality in an information and knowledge-driven society including big data and multi-source statistics, to governance and management aspects like the ones linked to the ESS Vision 2020 or the lessons learned from 2013–2015 peer reviews in the European Statistical System. More information available at: *http://www.q2016.es*.

The 22nd International Conference on Computational Statistics (COMPSTAT 2016) will take place at the Conference Centre of **Oviedo, Spain, during 23–26 August 2016**. The conference aims at bringing together researchers and practitioners to discuss recent developments in computational methods, methodology for data analysis and applications in statistics. The conference is organized by the University of Oviedo. More information available at: *http://www.compstat2016.org*.

The 19th International Scientific Conference Applications of Mathematics and Statistics in Economics (AMSE 2016) will be held in **Banska Stiavnica, Slovakia, from 31st August to 4th September 2016**. These conferences are organized each year by three Faculties of three Universities from three countries – University of Economics, Prague, Czech Republic, Matej Bel University in Banska Bystrica, Slovakia, and Wrocław University of Economics, Poland. More information available at: *http://amse.umb.sk*.

The 34th International Conference on Mathematical Methods in Economics (MME 2016) will take place in **Liberec, Czech Republic, during 6–9 September 2016**. The conference is a traditional meeting of professionals from universities and businesses interested in the theory and applications of operations research and econometrics. Conference is held under auspices of the Technical University of Liberec, Czech Republic, Czech Society for Operations Research, Slovak Society for Operations Research and the Czech Econometric Society. More information available at: *http://mme2016.tul.cz*.

The 24th Interdisciplinary Information Management Talks (IDIMT 2016) will be held in **Poděbrady, Czech Republic, from 7th to 9th September 2016**. More information available at: *http://www.idimt.org*.

The 10th International Days of Statistics and Economics (MSED 2016) will take place in **Prague, Czech Republic, during 8–10 September 2016**, organized by the Department of Statistics and Probability and the Department of Microeconomics, University of Economics, Prague, Czech Republic, Faculty of Economics, Technical University of Košice, Slovakia, and Ton Duc Thang University, Vietnam. The aim of the conference is to present and discuss current problems of statistics, demography, economics and management and their mutual interconnection. More information available at: *https://msed.vse.cz*.

Papers

We publish articles focused at theoretical and applied statistics, mathematical and statistical methods, conception of official (state) statistics, statistical education, applied economics and econometrics, economic, social and environmental analyses, economic indicators, social and environmental issues in terms of statistics or economics, and regional development issues.

The journal of *Statistika* has the following sections:
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The submission language is English only. Authors are expected to refer to a native language speaker in case they are not sure of language quality of their papers.

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Title (e.g. On Laconic and Informative Titles) — Authors and Contacts — Abstract (max. 160 words) — Keywords (max. 6 words / phrases) — JEL classification code — Introduction — … — Conclusion — Annex — Acknowledgments — References — Tables and Figures

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Footnotes should be used sparingly. Do not use endnotes. Do not use footnotes for citing references (except headings).

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Place reference in the text enclosing authors' names and the year of the reference, e.g. "White (2009) points out that…", "… recent literature (Atkinson et Black, 2010a, 2010b, 2011, Chase et al., 2011, pp. 12–14) conclude…". Note the use of alphabetical order. Include page numbers if appropriate.

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Journal of Statistika | Czech Statistical Office
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Managing Editor: Jiří Novotný
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e-mail: statistika.journal@czso.cz
web: www.czso.cz/statistika_journal
address: Czech Statistical Office | Na padesátém 81 | 100 82 Prague 10 | Czech Republic

Subscription price (4 issues yearly)
CZK 372 (incl. postage) for the Czech Republic,
EUR 110 or USD 165 (incl. postage) for other countries.
Printed copies can be bought at the Publications Shop of the Czech Statistical Office (CZK 66 per copy).
address: Na padesátém 81 | 100 82 Prague 10 | Czech Republic

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fax: (+420) 234 035 207
e-mail: myris@myris.cz

Design: Toman Design
Layout: Ondřej Pazdera
Typesetting: Chráněná grafická dílna Slunečnice, David Hošek
Print: Czech Statistical Office

96th year of the series of professional statistics and economy journals of the State Statistical Service in the Czech Republic: ***Statistika*** (since 1964), ***Statistika a kontrola*** (1962–1963), ***Statistický obzor*** (1931–1961) and ***Československý statistický věstník*** (1920–1930).

Published by the Czech Statistical Office
ISSN 1804-8765 (Online)
ISSN 0322-788X (Print)
Reg. MK CR E 4684