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Security of the Population in the Czech Republic from the Aspect of Crime and Penitentiary System

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Abstract

The empirical study concerning wide area of security of the Czech population deals with both its aspects – crime and prison population. First, we have the picture of macro-economic view on the issues through the international comparison of government expenditures on individual areas of public order and security. More comprehensive part of the paper maps out the development of registered and cleared-up crime in the Czech Republic by main types, it pays attention to selected groups of perpetrators (children, juveniles, criminal repeaters) and also its significant regional dimensions, including attempts to explain it. Overwhelming quantitative view on crime is extended also by subjective evaluation of security of population near their residence. Significance of qualitative view increases mainly in attempt to make international comparison where traditional "hard" data on crime hit different legal environment also in geographically close countries within the EU. Social pathology and criminal legislation influence also the composition of prison population which is assessed from the aspect of sex, age, citizenship, education, the level of imposed sentence and criminal history. Increasing number of prisoners has recently negatively influenced the occupancy rate of prisons, which raises questions concerning sustainability of financing of penitentiary system especially in the period of total economic depression. Presidential amnesty in January 2013 released more than a quarter of all prisoners which resulted in one-shot significant decrease in occupancy rate. This event modified also the structure of prison population. The position of the Czech Republic within EU improved significantly in terms of occupancy rate, but still remained unfavourable as regards total rate of imprisonment of population.

Keywords

Public order and security, crime, prison issues, penitentiary system, public expenditure, regional difference, Czech Republic, European countries

JEL code

D 63, H 56, J 19, K14, R 23

INTRODUCTION

One of the most important attributes of the quality of life is an internal security (safety) of the population of a given country. It can be assessed on the basis of "hard" data (based on revealed crimes) and also according to subjective perception of security by individuals. Analysis is focused on selected aspects of

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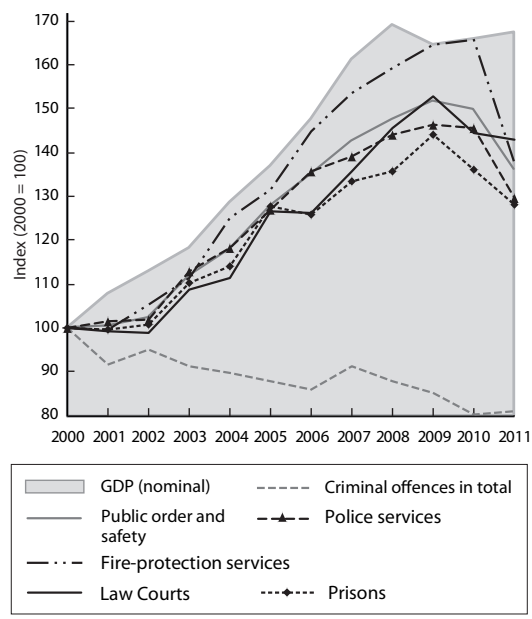
these issues using multi-source data with the attempt to reach more complex view. Crime and penitentiary system are examined from the aspect of disparities in individual regions of the Czech Republic and also from international aspect which is, however, in majority of indicators limited by methodological inconsistencies. Analysis is extended by comparisons of public order and security expenditures. These are also supplied with comment on possibilities of public finance which depend on the performance of the Czech economy. Analysis is focused on data in time series from 2000 and in majority of areas it brings also fresh data for 2011 or 2012 (data concerning prison population were updated to reflect significant impact of presidential amnesty declared in January 2013). Most of the data was obtained from the "official sources" – *Police Presidium of the CR or Prison Service of the CR*. By means of basic methods of descriptive statistics we analysed both volumes and structure of reported or cleared-up crimes as well as imprisoned population.

1 EXPENDITURES ON PUBLIC ORDER AND SECURITY

According to preliminary results of tables related to the sector of government institutions accounts (including except for central government also local government) in 2011 in the Czech Republic the total of CZK 70.2 billion was allocated to public order and (internal) security. Slightly over a half of this amount swallowed the expenditures on police services, one eighth went to fire safety, one sixth to courts including prosecutor's' offices and one tenth to prison issues. The growth rate of total nominal government expenditures on public order and security for the last decade fell behind the GDP growth. Taking into account of the assessed partial groups of expenditures only expenditure on fire safety maintained (till 2010) nominal growth-rate of GDP, on the other hand, the growth-rate of expenditure on prison system was by 65% slower in comparison to the output of the whole economy. Overall economic slowdown had negative effect on government expenditures on public order and security. In recent years nominal GDP of Czech economy has stagnated while expenditures on public order and safety has been reduced significantly – between years 2009 and 2011 by 10% (on fire safety by 16%, on penitentiary system only by 7% - deeper reduction was prevented only by the stable increase of "prison population").

Total government expenditures on public order and security reached in 2010 in the Czech Republic 2.04% of the GDP. Compared to the situation in 2000 expenditures were by 0.22 p.p. lower, minimum in the last decade was reached in 2008. In most EU countries in the last decade the share of expenditures on public order and security moderately increased – most in Greece and Portugal, the more sensitive drop than in the Czech Republic was recorded in the Baltics. The Czech Republic, like most of new EU members, keeps in terms of its share of expenses slightly above the EU average from which the Northern countries, otherwise very "budgetary generous", get out by their low expenditures. Strong budgetary pressure across EU members led in 2011

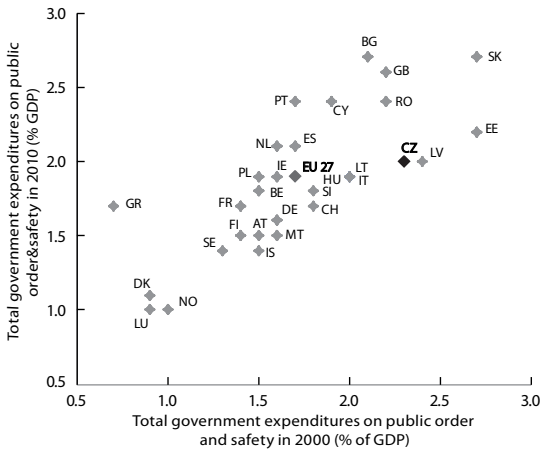
Figure 1 Total registered crime and government expenditures by selected items* (2000 = 100)



* Based on International Classification of the Functions of Public Entities (COFOG).

Source: CZSO, Eurostat, own calculations

Figure 2 Selected countries – total government expenditures on public order and safety (in % of GDP, 2010 compared to 2000)

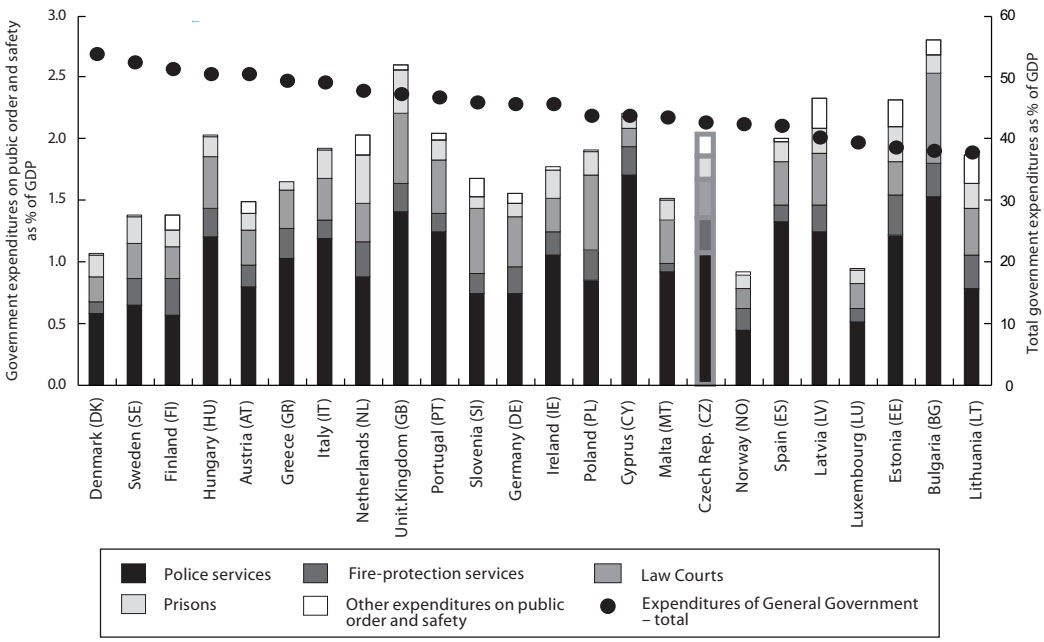


Source: CZSO, Eurostat, own calculations

to expenditure cuts on public order and security. In the CR these expenditures decreased to 1.84% of the GDP.

In the structure of government expenditures on public order and security in the European countries, given the moderately above-a-half share, significantly prevail expenditures on police service (see Figure 3). Expenses on police swallowed in 2006–2010 in Cyprus almost four fifths of all expenditures on public orders and security, in Germany and in Northern Europe expenditures represent 45%. The second most expensive item in majority of countries form expenses on justice, which draw out around one fifth of all expenses on public order and security. The Czech Republic with the structure of its government expenditures on public order and security does not differ much from majority of European countries.

Figure 3 Expenditures of the government sector on selected items of security & public order and total government expenditures in selected European countries (% of GDP, average in the period 2006–2010)



Source: CZSO, Eurostat, own calculations

In the group of 24 assessed countries (mostly from EU, see Figure 3) the Czech Republic allocated in the period 2006–2010 in relation to GDP bigger amount of public expenditures on fire safety (0.28% to

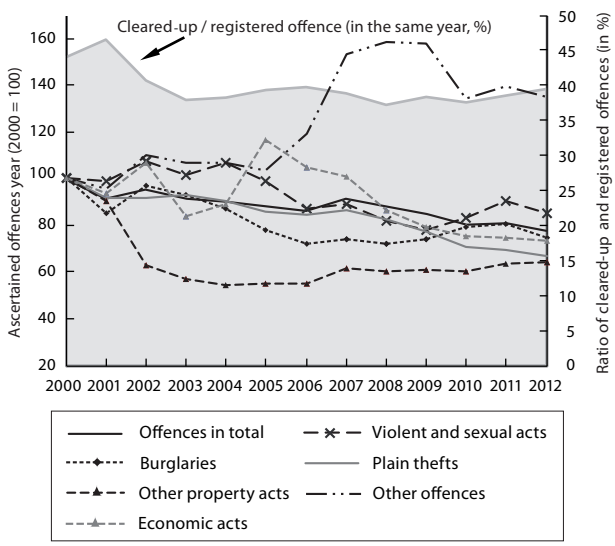
0.20% in EU), and lower on justice (0.32% to 0.40%). In justice expenditures there exist big disparities – Bulgaria expended on this item 0.73% of GDP while the Northern countries 0.2–0.3% of GDP. In percentage of expenditures on police or penitentiary system in the assessed period the Czech Republic did not differ much from the EU average and like majority of "new member" EU countries expand yearly on all areas of public order and security more than 2% of GDP which ranks it among the above-average countries within the EU. From among the "old members" also the Great Britain (2.6%), the Netherlands and Portugal belong to those with higher expenditures. While big expenditures of the Great Britain show in all main areas of security, in the Netherlands they are obvious only for fire safety and especially for penitentiary system (expenditures on penitentiary system here as in one of a few European countries exceed the expenditures on justice).

2 STRUCTURE AND INTENSITY OF CRIME IN THE CZECH REPUBLIC

In actual fact, government expenditures on public order and safety are related mainly to crime (delinquency). This represents in current globalized world a serious social phenomenon. Free movement of labour force and capital at one hand enable more intensive interconnection of economy and individuals, at the other hand, it has many negative consequences (e.g. illegal migration streams or development of organised highly sophisticated forms of economic crime).

Besides external influence crime in individual countries is bound to the effect of many national specific factors. Important role in the Czech Republic belongs to criminal legislation (specification of offences, relation between transgressions and offences, determination of the term of punishment) as well as the work of investigative, prosecuting and adjudicating bodies (number of policemen "in the field", their qualification and mutual co-operation in revealing increasingly sophisticated forms of economic and property crimes, including organized crime; how quickly justice works). This is related to confidence of persons (who suffered damage) in work of the above institutions which shows e.g. by willingness to report "minor" offences. To make taboo of some offences or insufficient protection of their victims (so called secondary victimization e.g. in case of domestic violence) shows continuing effect. Indisputable is also the impact of current climate in the society, worsened by social and economic situation (surviving of relatively high unemployment, drop of real purchase power of a big percentage of the population) as well as publicizing of increasing social tensions in certain troublesome regions. Dynamics of total number of offences is generally related to shifts in age structure of population and marginally also to growing foreign migration.

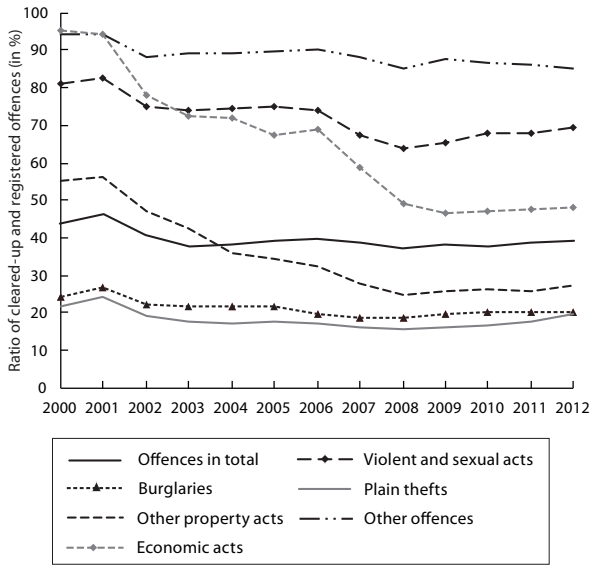
Figure 4 Development of main types of registered (ascertained) offences in the CR



Source: Police Presidium of the CR, own calculations

In 2011 in the Czech Republic police bodies registered 317.2 thousand offences, i.e. by 1.2% more, year-on year. Intensity of crime was by whole one fourth below the level recorded in 1999, when the big growth of crime started along with transformation of economy (related among other things with big

Figure 5 Relation of cleared-up and registered offences in respective year in CR

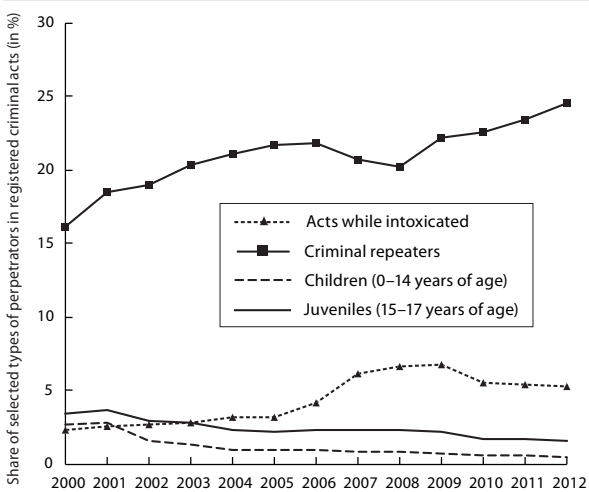


Source: Police Presidium of the CR, own calculations

property transfers) culminated. For the last decade this referred for only third y-o-y crime growth (previous two growths in 2002 and 2007, however, by their size slightly exceeded current moderate increase of crime).

Behind the y-o-y increase of registered crimes in 2011 there was mainly the increase of frequency of revealed acts of violence (by 7%), offences against morality (by 15%) and burglaries (by 2%). This did not refer to a random deviation since in all these categories of delinquency a moderate growth has been registered as early as since 2009 (in case of acts of violence since 2010). From among other acts (according to individual sections) increasing was the number of registered cases of "breach of the peace" (in 2011 by one third above the level of 2009) and "illegal production, possession and distribution of narcotics, psychotropic substances and poisons" (compared to 2007 the number was by 40% bigger) – in both cases in 2011 the level of registered crime was close to the level in 2000. The period of total economic slow-down is accompanied by growth of cases of "perverting of the course of justice" (between years 2008 and 2011 growth by 50%) and notably "evasion of alimony payments (i.e. child neglect/desertion)" (between years 2008 and 2011 growth by 150% and on the contrary, in the period of economic growth in 2004–2008 the fall by almost one fifth was recorded). Both previous violations of laws are specific not only by high clear-up rate but mainly by high share of criminal repeaters (in long-term around 60%) among their perpetrators who often end up with unconditional sentences and extend so far high number of "prison population".

Figure 6 Share of selected types of perpetrators in total crime in the CR



Source: Police Presidium of the CR, own calculations

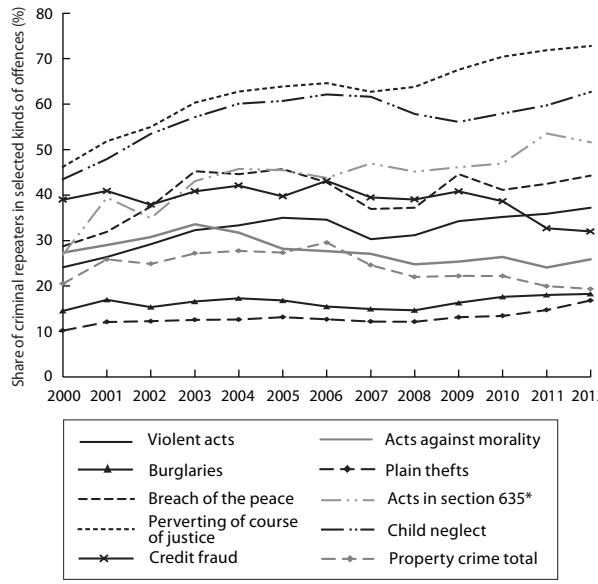
According to preliminary results, in 2012 the total number of registered offences was 4% lower than previous year. This can be assessed as a return on long-term trajectory. Police bodies revealed fewer violent and sexual acts (–5%), number of burglaries dropped (–7%) after three-year period of growth, also plain thefts were less frequent. On contrary stable moderate growth of other property acts continued (mainly frauds).

Growth of share of criminal repeaters in registered offences is a long-term phenomenon in the CR, since 2000 it

has been temporarily suspended only in 2007–2008. In 2012 criminal repeaters represented almost one quarter of all offences. The growing influence of recidivism (repeated crime) was caused by combination of two factors.

First, due to deeper drop of incidence of acts with low share of repeated offenders. This referred mainly to property offences – forming two thirds of total crime – which dropped as a whole between the years 2000–2012 by almost 32% while the total crime only by 22%. Property offences at the same time show long-term falling clear-up rate which in 2012 did not reach even 20%.[3] It is therefore possible that the drop of registered property acts is partly caused by lower readiness of the injured persons to report these acts to the police. The second course of increasing repeated crime subsists in the growth of absolute number of acts committed by criminal repeaters which increased mainly in the first half of the assessed decade (from 63 thousand to 75 thousand). This was contributed to not only by acts of violence and some economic offences (credit and other frauds) but mainly the above mentioned other criminal acts (breach of the peace, drug abuse, perverting of the course of justice, desertion, endangerment under the influence of toxic substances or alcoholism).

Figure 7 Share of criminal repeaters in selected kinds of criminal activity in the CR[2]



* Acts in section 635: Unlicensed manufacture and possession of psychotropic matters and poisons.

Source: Police Presidium of the CR, own calculations

The growth of share of criminal activity committed under the influence of alcohol was related to the increasing share of drivers at fault who were intoxicated. Another factor was a fast growing number of registered acts "endangerment under the influence of toxic substances or alcoholism" and not falling number of other acts where alcohol played an important role (breach of the peace and some kinds of acts of violence). Changes in number of registered crime under the influence of alcohol might reflect also the inconsistencies applied in alcohol test made for perpetrators immediately after their detention.

Share of the youth and children in total crime is falling moderately on long-term basis. One of reasons may also be a low birth-rate implicating decrease in the number of potential perpetrators (between the yeas 2000 and 2012 by 230 thousand (11.5%). The share of juvenile perpetrators dropped in all main categories of criminal activity (mainly for those who at the beginning of past decade reached more than 10% of share in all the perpetrators – i.e. for the acts of violence and against morality and for specific acts such as breach of the peace, sprayers, drug crime and some minor thefts). In case of juvenile delinquency

[2] Criminal activity as mentioned in Figure 7 in connection with drugs refers to section 635 (illegal production, possession and distribution of narcotics, psychotropic substances and poisons).

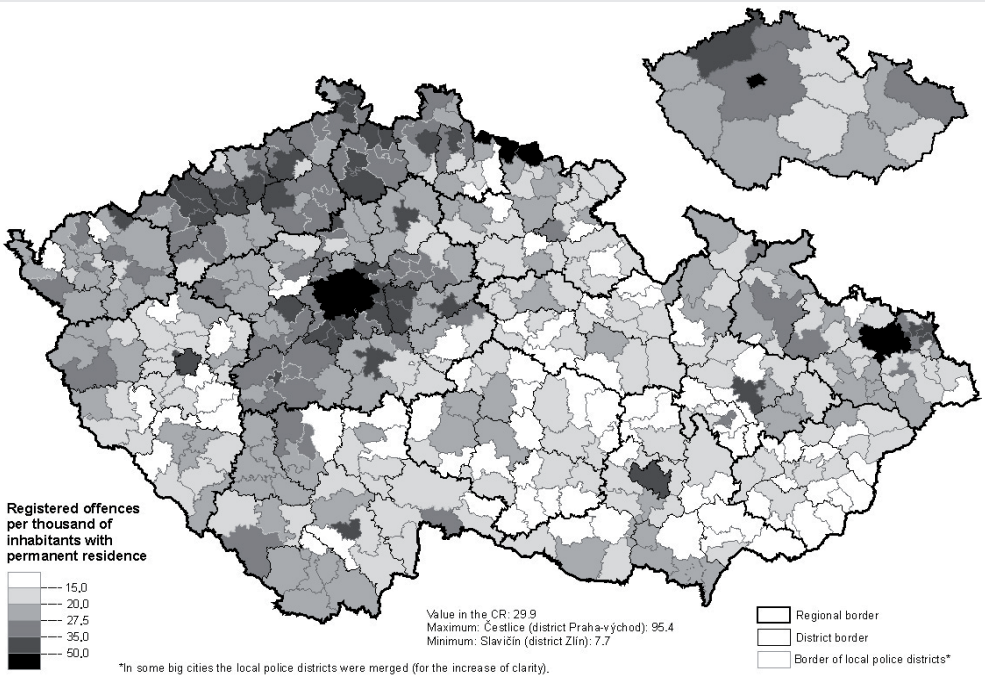
[3] Clear-up rate is understood as the relationship of clear-up and registered acts at the same calendar year. This does not refer to „net clear-up rate"(this would have to be calculated by more sophisticated cohort method) because a part of cleared-up acts in the monitored year is "overvalued" by offences recorded in the previous years and on the other hand is "underestimated" by offences recorded at the same calendar year but revealed as late as in subsequent years. For the purpose of gross comparisons of basic categories of offences in long-term aspect can be however considered the created indicator as sufficient.

legal assessment of acts[4] (e.g. the difference between an offence and transgression) is important and also trend to apply educational and less repressive forms of correction of perpetrator. Along with these general factors also specific impacts related closely with specific locality (e.g. program of crime prevention at local or regional level) are applied.

3 STRUCTURE AND INTENSITY OF CRIME AT REGIONAL LEVEL

Regional disparities represent one of important features of registered (ascertained) crime. For their assessment analysis at the level of regions (enabling to map out current trend also according to basic kinds of criminal activity) was used. We also dealt with the level of lower territorial units (local police districts),[5] which we assessed as one whole (i.e. crime in total) in respect of lower frequency of criminal acts. Due to changing borders of individual district departments only the period 2010–2011 was analysed.

Map 1 Ascertained offences per 1000 inhabitants (average for 2010 and 2011).



Source: Police Presidium of the CR, own calculations

The above map shows that from the above-average crime suffers the population of most regional cities (with *Prague* and *Ostrava* at the first place), practically the whole *Ústecký* region and western part of *Liberecký* region, wider surroundings of *Prague*, also *Příbram* distirct and selectively some of other border districts (near *Cheb, Tachov, Břeclav*). On the other hand, relatively most secure territory is the

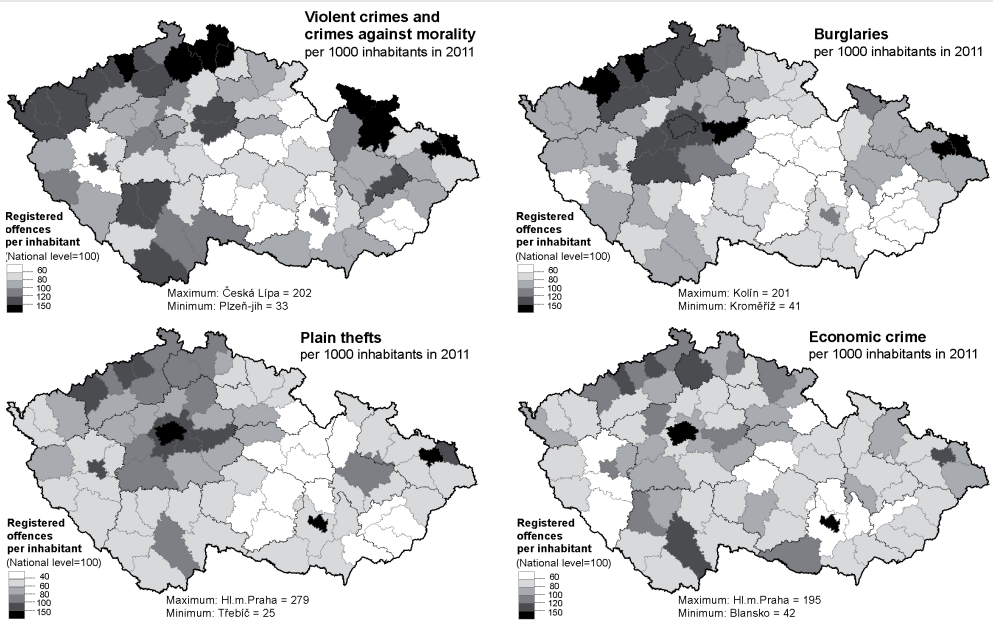
[4] E.g. No. 218/2003 Sb. (regulating the level of social danger and manner of treating children and minors who committed offences) significantly supporting educational measures.

[5] Police Presidium of the CR keeps records of registered crime (on the level of individual sections) up to the level of more than 550 district police departments. With respect to more frequent changes of borders of these districts within big cities, the problem of allocation of corresponding number of residents and also to significant disparities between "de-jure population" (permanent residents) "de-facto population" (which is more suitable for measuring of intensity of crime) in big cities these districts were merged. Thereby, we had about 430 of territorial units under which the intensity of crime was assessed (see Map 1).

southern part of eastern Bohemia and especially whole *Vysočina* region and rural submontane regions of Moravian and Silesian borderland. The level of criminality is influenced by complex multifactor and partly also inertial phenomena. It is not surprising that its territorial structure has not changed much for the last decade in basic above mentioned features.

Among more important recent changes it should be mentioned the growth of intensity of crime in *Ostrava, Karviná* and *Bruntál* districts especially in the last five years (peaked in 2010–11). An increasing trend showed crimes also in *Kolín* and *Dečín* districts (where the y-o-y growth of crime affected almost the whole district despite the fact that high intensity of crime survived in the region of *Šluknov* and *Varnsdorf* which are known from the media). Some big cities with the highest crime-rate in the whole CR succeeded in reducing the number of registered offences down to a half (*Mladá Boleslav*). Recent developments in *Mladá Boleslav* was in contradiction with near *Kolín* (with also important automotive industry) where after the entry of strong foreign investor and subsequent migration of workers the crime increased. One third of the drop of crime since 2000 was recorded in *Karlovy Vary* or *Tábor*, higher dynamics of drop compared to the CR was maintained also by other cities (and their neighbourhood): *Kladno, Teplice, Pardubice, Hodonín, Vsetín, Zlín, Opava*.

Map 2 Difference in intensities of selected types of criminal activity by districts in 2011.



Source: Police Presidium of the CR, own calculations

In addition to general factors with the nation wide effect (mentioned in introduction to this chapter) we should point out also other ones which might explain the differences of criminal activity at regional or local level. The key role is attributed to social structure of the population: mainly higher level of education, low migration turnover, phenomenon of patriotism or religiousness – these mitigate the crime. Complex conditionality of crime is denuded by unfavourable situation in big cities (with higher education of the population) where due to the influence of increased anonymity the drop of general social control takes place. Criminal activity is also contributed to population with short stay (tourists, commuters to work and schools) and also segments of population which are difficult to quantify (illegal migrants, homeless people).

Comparison of the number of offences to the population with permanent residence has in big cities its limits like in areas with intensive tourism and leisure time activities (i.e. border mountain areas, southern surroundings of *Prague*). The quality of measurement of crime intensity might be improved in the near future by final results of the population census, where population was according to EU standards classified by the place of usual residence. From among other factors co-shaping the crime the influence of preventive measures (e.g. camera systems or more generally, action programmes of struggle against crime and social exclusion) cannot be neglected. Finally, the criminal activity is certainly stimulated by worsened physical quality of living and also by quality, cleanliness and lay-out of public spaces (streets, play-ground, greenery, etc). Many of these factors are affected by not only by national policy but predominantly by regional or local policy.

Looking at main kinds of criminal activity (see Map 2) we find out that its territorial structure differs. "The phenomenon of big cities" are mainly plain thefts (typical pick pocketing, stealing of items from car and also car thefts). Almost one third of them was recorded in *Prague*, three biggest cities in the CR contributed in 2011 to the republic total of plain thefts by 47%. Plain thefts significantly co-create a picture of total crime to which they contribute by 40%. In case of burglaries (forming one fifth of total crime) the dominant position is attributed in addition to the biggest cities also to southern part of the *Středočeský* region, to the whole area of *Ústecký* region and western part of the *Liberecký* region. In border areas there are higher intensities of violent crimes and acts against morality (these areas including also territories where the total intensity of crime is rather lower in long-term basis (i.e. *South Bohemia* borderland, *Jesenicko-Bruntálsko*).

The last important group – economic crime – which to the total crime contributes by one tenth, is typical mainly of big cities and their territorial structure comes close to plain thefts. Dominant position of the biggest cities was, however against current thefts lower. *Prague* contributed to the total registered economic crime in 2011 by one fifth and along with *Brno* and *Ostrava* by one third. The share of three biggest cities in the Czech Republic in the total of registered economic crimes is increasing, on the long-term basis since those in 2000 concentrated only one fifth of this criminal activity. This fact may relate to long-term change of the structure of committed economic crimes – birth of new forms of criminal activity (e.g. subvention fraud) and strengthening of influence of sophisticated offences (e.g. criminal acts related with currency and means of payment including credit cards). Changes of structure of economic crime are probably related also to certain changes of structure of perpetrators (increasing of crime committed by "white collars"), including its territorial structure. Change of structure of acts within economic crime is reflected in sharp drop in cleared-up (for the last decade the clear-up rate dropped down to a half) party due to increasing lapse of time between detection and clear-up of criminal activity.

4 RELATION OF REGISTERED AND SUBJECTIVELY PERCEIVED CRIME

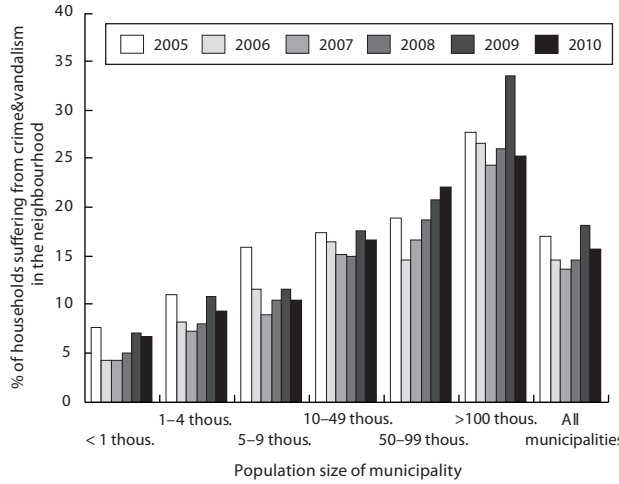
The above-mentioned results reflect the fact on the basis of registered or cleared-up crime. Since it refers to "hard data" it can be hardly presumed that we could only by their means obtain the exhaustive picture of total actual crime. This can bring closer the qualitative views, i.e. subjective perception of this phenomenon by (local) population. The advantage of this approach is that among other things it may map out criminal acts incl. "mere" transgressions (which escape from police records) has, however, also its own limits.[6] For the purpose of subjective assessment of crime the results of survey of the CZSO "Living con-

[6] It should be taken into account that statements of residents may be burdened by certain mistake resulting from insufficient knowledge or disinterest in the given range of problems or, on the contrary, from uncritical assessment of the situation related to exaggeration of own experience, generalization of reality from immediate neighbourhood to wider area (quarter, city, region). The problem is also availability of data, the information is possible to obtain only by sample survey which is always burdened by certain error in relation to the size of surveyed sample of the population and selected method for sampling.

ditions" were used where respondents answered also to the question whether or not they consider vandalism and crime in the neighbourhood of their residence as problem.

Along with increasing size of municipality of residence the households report bigger dissatisfaction with crime and vandalism near their residence (in cities with over 100 thousand inhabitants their share is on long-term basis four times bigger than in rural municipalities). Subjective perception of crime was moderately improving (during 2005–8), in subsequent years of economic slow-down, however, households began to perceive this problem in their neighbourhood as more burning (regarding the size of their domicile). Although citizens of most of the regions subjectively assessed crime in 2010 slightly better that five years ago (which corresponded with the general drop of registered criminal activity). Exception formed regions with lower registered crime: the Jihočeský region and region in the east of Bohemia and also Vysočina region where parallel growth of registered crime was recorded. The sequence of regions by objectively registered criminal activity well corresponds with the ranking by subjective perception of crime (except for three regions whose citizens fell problems with crime in their neighbourhood less). The reason for this partial disharmony may by the fact that the inhabitants assessed their situation only in their neighbourhood (not in the whole region) and might include wider range of criminal behaviour.

Figure 8 Share of households suffering from crime and vandalism in the neighbourhood (by size of municipality of residence)

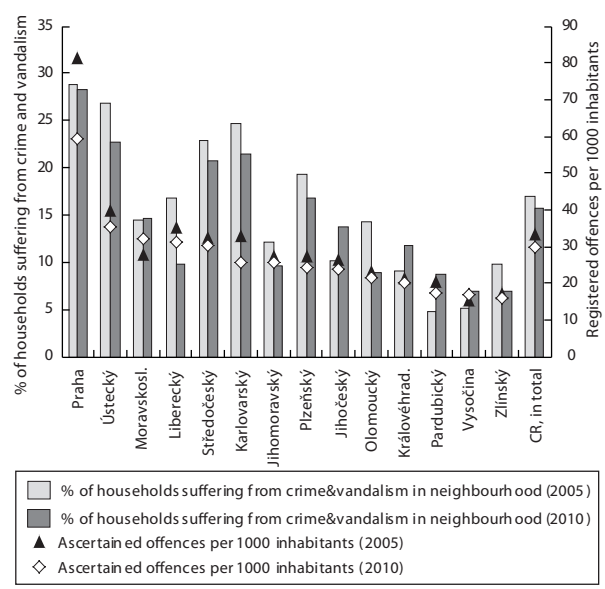


Source: Police Presidium of the CR, CZSO (survey Living conditions), own calculations

5 CRIME IN INTERNATIONAL COMPARISON

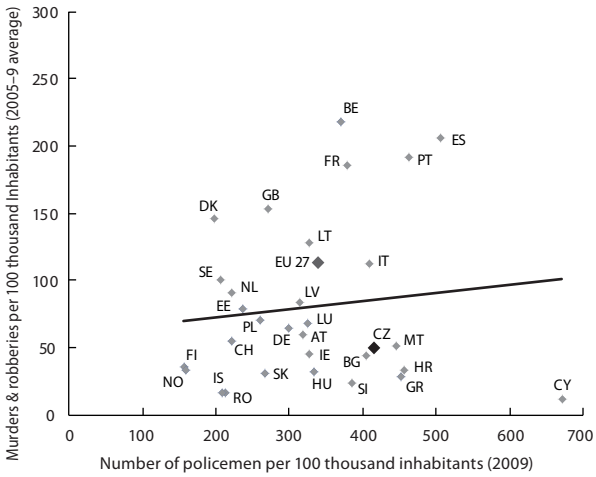
If we try to map out the phenomenon of crime in the widest possible context we soon must come across the problems arising in attempts to make more profound international comparison. Even though individual European countries have relatively detailed criminal records their data are often incomparable due to the influence of different definition of

Figure 9 Relationship of subjectively perceived crime near residence and registered crime by regions of the CR



Source: Police Presidium of the CR, CZSO (survey Living conditions), own calculations

Figure 10 Number of policemen and number of registered murders and robberies in selected European countries (per 100 thousand of population)[8]



Source: Eurostat, own calculations

criminal legal acts, relationship between criminal activity and transgressions, etc. Equally important are also different legal practice (enforcement of punishments or records of actual criminal activity). If we assess individual countries only on the basis of total crime recorded by police bodies we would easily come to paradoxical conclusions.[7] We may, however, suppose that in certain segment of registered offences (mainly the most serious) their record rate also in the countries with generally lower quality of record keeping (south European countries, the Balkan) is sufficient enough to be able to carry out at least general comparison across Europe.

On the basis or recorded murders and robberies (with a 2% share in total crime in the EU countries) per head bigger figures are recorded only in member EU countries traditionally associated with strong ethnic immigration (Britain, France, Belgium, countries of the Pyrenees peninsula). Relatively low figures of murders and robberies are typical of majority of northern countries (where they are in contrast to high total recorded criminal acts) and also "new" EU member countries (except for the Baltic states with high number of recorded murders). The Czech Republic does not go beyond the borders of general characteristic of new member countries, by relative number of most serious offences it belongs (along with the whole area of Central Europe) to „safer" areas of the continent. From among our neighbours relatively higher number of murders and robberies are recorded only in Poland, however, even here less than in the whole EU.

If we relate roughly 40 thousand of policemen to the size of the population in the Czech Republic we come (in the context of EU alongside with numerous representatives of southern Europe) to the countries with relatively higher number of police corps. Relative number of policemen was according to data from the year 2009 (last available) also for all our neighbours lower. In Europe it is possible to see a north-south gradient, in northern countries (also in the GB) there was smaller number of policemen per head.

In the group of thirty European countries no direct linear dependence of the number of policemen (per head) on any other of the main kinds of registered crime was proven. If we rule out Cyprus from the

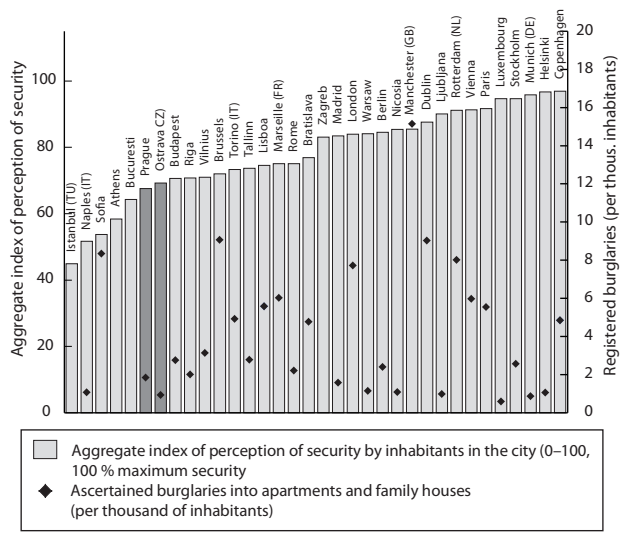
[7] It is supported by the fact that according to the number of all recorded offences per heard Sweden shows the biggest figures (triple of the level in EU), at the opposite end of the spectrum there is majority of Balkan countries whose crime rate according to the official statistics does not reach even one tenth of the level in Sweden. In ten European countries with the highest assessed crime there are all northern countries, Benelux countries and most of Alpine countries (e.g. Switzerland). Hinted differences attest to the quality (completeness) of its record by means of long-term system of registers rather than to total real crime. Certain role is played also by better willingness of the population to co-operate with the bodies caring for public order and safety which is related to confidence in their activity.

[8] List of countries and their abbreviations (pursuant to valid nomenclature of CZEM countries): Belgium (BE), Bulgaria (BG), Czech Republic (CZ), Denmark (DK), Estonia (EE), Finland (FI), France (FR), Croatia (HR), Ireland (IE), Island (IS), Italy (IT). Cyprus (CY), Lithuania (LT), Latvia (LV), Luxembourg (LU), Hungary (HU), Malta (MT), Germany (DE), Netherlands (NL), Norway (NO), Poland (PL), Portugal (PT), Austria (AT), Rumania (RO), Greece (GR), Slovakia (SK), Slovenia (SI), Great Britain (GB), Spain (ES), Sweden (SE), Switzerland (CH).

group (with very specific political situation on long-term basis) we may find weaker relationship[10] only with number of registered robberies (see Figure 10).

Slightly different view on the assessment of the scope of real crime may provide different sociological surveys. On the basis of survey by Eurostat (conducted in 2006 and 2009 to collect "soft" data for urban statistics) less favourable position of Prague among European metropolis was obvious (Question: "How do you assess security and crime in the city you live?"[11]). Compared to Prague, worse results according to the survey were recorded for some big cities in the Balkans or big Italian cities. At the other hand, similar position as Prague reached Budapest or capitals in the Baltics. The best rating received security in the capitals in the north of Europe and in some bigger cities (Amsterdam, Munich, Hamburg) where the level of total official (i.e registered) crime was mostly above average. Behind this apparent discrepancy there is a fact that subjective assessment of security by citizens (besides level or real crime) reflects also more general factors (perception of the quality of work of bodies responsible for public order, quality of integration of foreigners, care for public areas in the city, proper preparation of crime-prevention programmes etc.). More objective data on security of the population in the advanced European countries may provide relative numbers of prisoners (see Figure 12). This comparison should be, however, considered as only general since the numbers of prisoners are significantly influenced by criminal legislation and its application in different countries (e.g. application of alternative punishment).

Figure 11 Subjective assessment of security by inhabitants of European cities and intensity of recorded burglaries into apartments and houses (2006–2009)[9]



Source: Eurostat, own calculations

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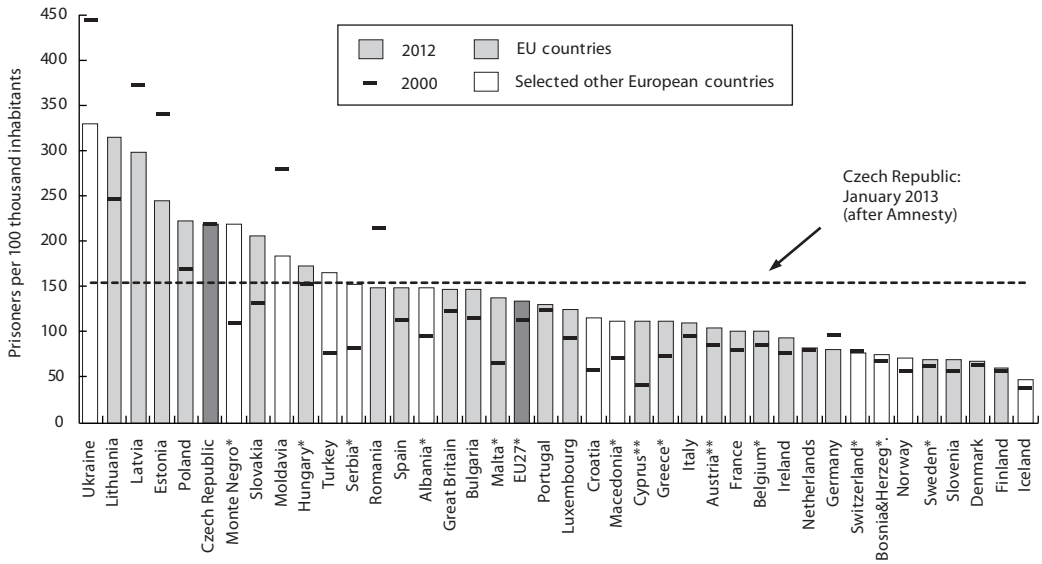
[9] Data proceeded from the series „European perception survey", organized within the project „Urban Audit" by Eurostat (random interviewing of households by phone) in the years 2006 and 2009. The aim of the questionnaire was to obtain from the population of a hundred of important European cities (capitals, in bigger countries also other selected important cities) their opinion on widely conceived quality of life in their city.

[10] Pearson's correlation coefficient between the number of policemen and registered robberies (in both cases related to citizens) recorded in 2009 the value +0.35. The relationship between the number of policemen with total registered crime (–0.43) reflect the situation mainly in northern countries where the influence of lower numbers of policemen is combined with relatively higher total registered crime (partly due to more consistence records and party due to different legal definitions of criminal activity – in total crime more probably are more often represented relatively "minor" acts, e.g. transgressions).

[11] In Prague in 2009 answered 30% of respondents that the city is generally safe, 35% considered the city safe only time from time and the same share of the inquired perceived security of city as positive seldom or not at all. In Ostrava corresponding shares of responses were 30%, 37% and 30%. In comparison with almost 80 surveyed cities (capitals of the EU countries, including Turkey and Croatia and other big EU cities) the situation in two our big cities was less favourable since the total average value (each city had the same weight) for the surveyed cities was 50% (mostly safe city), 33% (sometimes safe) and 15% (rarely or not safe at all). Between the years 2006 and 2009 only small changes (at European level and also for Czech cities) can be understood from the respondents' answers.

Figure 12 Number of prisoners[12] per 100 thousand inhabitants in selected European countries



** Latest data for 2010, * data for 2011.

Source: International Centre for Prison Studies <http://www.prisonstudies.org/info/worldbrief/wpb_country.php?country=158>, own calculations

6 PENITENTIARY SYSTEM IN THE CZECH REPUBLIC

The number of prisoners in the Czech Republic was increasing since 2003 in spite of long-term falling registered crime. The number of imprisoned persons on the territory of the Czech Republic[13] recorded except for 2006 the y-o-y continuous growth for almost ten years. In the last months the growth rate of the number of prisoners speeded up. While by the end of 2010 the total of 21 892 prisoners were in the Czech prisons, a year later it was 23 154 persons. The growth continued also in the first half of 2012 (almost +500 prisoners), but at the end of 2012 the "prison population" dropped to 22 609. Both total number of prisoners and their structure were significantly modified due to presidential amnesty declared at the beginning of 2013.

6.1 Development of the number and structure of prisoners

Total number of prisoners is a result of two partial components – number of accused persons (in custody) and the number of the imprisoned (convicted persons). These both components underwent for the last decade different paths. The number of persons in custody between the years 2000 and 2002 dropped by a half and decisively contributed at that time to the total decrease in the number of all prisoners. The drop was actually caused by legislative changes (especially Act No. 265/2001 Sb.) which make the conditions under which persons can be taken into custody stricter and regulated also the term of custody. Since 2003 the number of prisons in custody has stabilized, for males until 2007 the number has been slightly falling. The share of the accused in the total number of prisoners fell significantly, in 1998 the persons in custody formed almost one third of all prisoners, in 2011 only one tenth. In January 2013

[12] It includes all the accused (in custody) and sentenced adults or juvenile perpetrators of criminal acts who stay in prisons (including custodial and facilities for minors) or special hospital facilities (e.g. for drug addicts or mentally ill perpetrators). It does not include detained for non-criminal acts (i.e. during processes related to immigration proceedings).

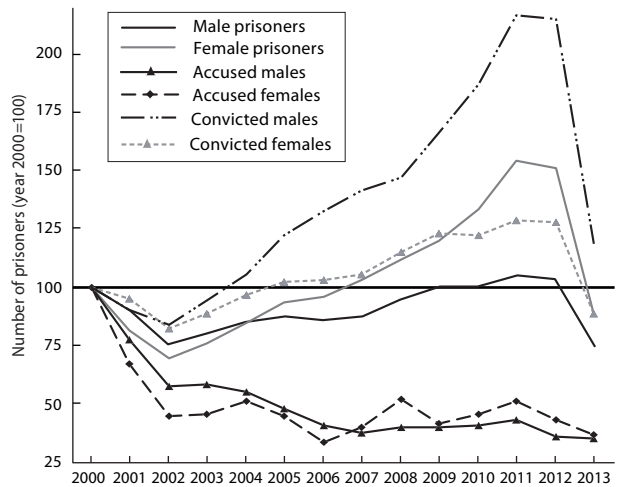
[13] More than one thousand of the Czech citizens are imprisons in aboard, those, however, were not included into this analysis.

the share of accused rose to 13%, since presidential amnesty reduced sharply figures of sentenced prisoners but had negligible impact on persons in custody (see Figure 13).

On the contrary, the numbers of sentenced prisoners has been constantly increasing since 2002, while increases reached the level of the 90th. In the last three years there was a sharp growth of sentenced women whose number almost doubled compared to 2005, however, their contribution to the total number of prisons in relatively low (by the end of 2011 women imprisoned contributed by almost 6.5% moderately exceeding the EU averages). Although the number of releases from prisons is slightly increasing on long-term basis (from 3.1 thousand in 2003 to 4.4 thousand in 2010), the decisive factor of the growth of the prison population are bigger numbers of persons starting to serve their sentence from civil life (e.g. persons for whom community work showed no effect, i.e. suspended sentences and sentences entailing community works which were therefore changed into unconditional sentences). Long-term stable growth of "prison population" was disrupted by presidential amnesty. In January 2013 more than 28% of sentenced prisoners were released. Some penitentiary establishments released almost 50% of prisons. Due to the uneven spatial distribution more than a third of all released prisoners left establishments in north-western part of Czechia (neighbouring with the Saxony).

Growth of prisoners in the CR in the last decade was only marginally affected by persons with foreign nationality. The number of foreigners in prison facilities in the CR in the period 2000–2007 was decreasing, on the contrary, the later growth due to its intensity slightly

Figure 13 Numbers of the accused (in custody) and convicted (sentenced) and the number of prisoners in the CR (as of 31 December* year 2000 = 100)

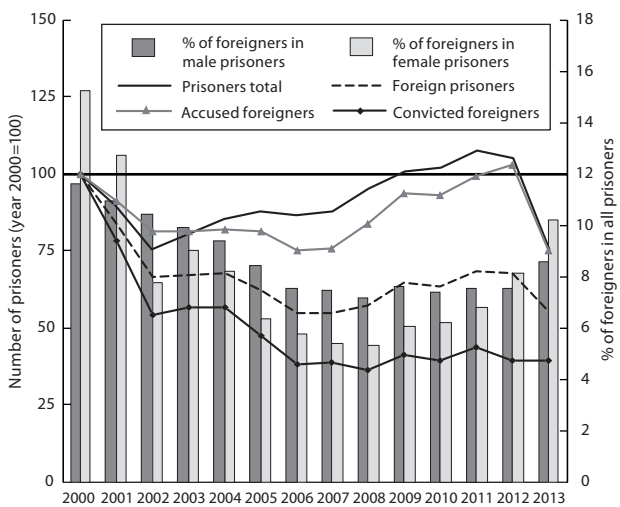


* Latest data: January 2013 (after Amnesty).

Note: A foreigner is a person with other than Czech citizenship; former nationals of the CSFR for whom it is not obvious from available documents whether they are citizens of the CR or SR, are not included into foreigners.

Source: Prison Service of the CR, own calculations

Figure 14 Numbers of the accused and sentenced foreigners and the share of foreigners in Czech prisons (as of 31 December* year 2000 = 100)

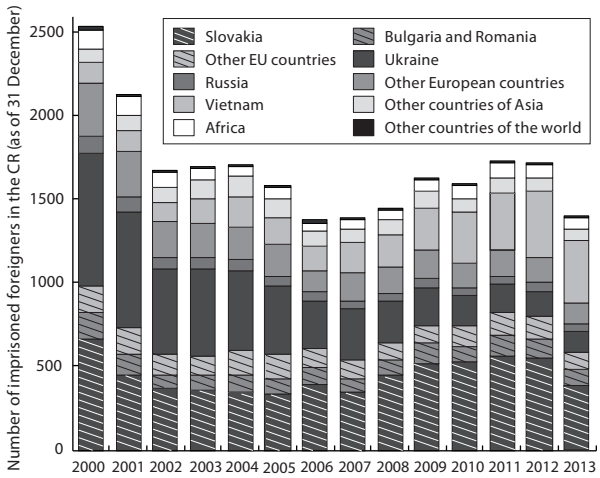


* Latest data: January 2013 (after Amnesty).

Note: A foreigner is a person with other than Czech citizenship; former nationals of the CSFR for whom it is not obvious from available documents whether they are citizens of the CR or SR, are not included into foreigners.

Source: Prison Service of the CR, own calculations

Figure 15 Numbers of prisoners – foreigners in the CR by citizenship (as of 31 December)*

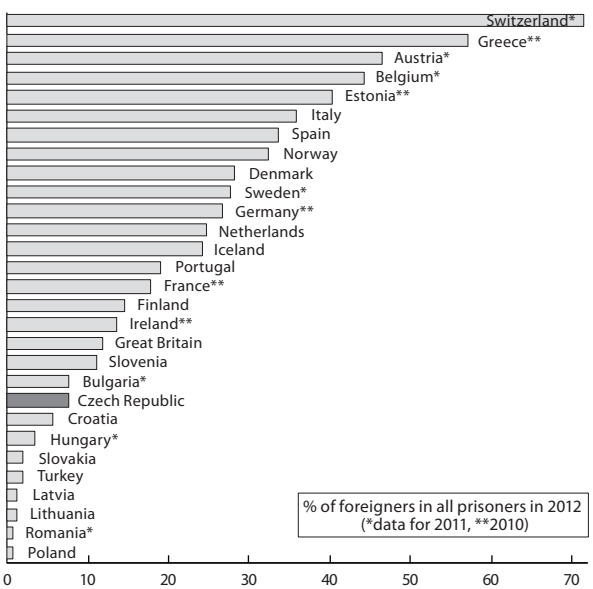


* Latest data: January 2013 (after Amnesty).
Source: Prison Service of the CR, own calculations, International Centre for Prison Studies

exceeded the growth-rates showed by prisoners with Czech citizenship. By the end of 2012 in Czech prisons the total of 1715 foreigners were served their sentence, i.e. by one third less than at the end of 2000. The key factor behind the drop of imprisoned foreigners was lower number of the accused who are placed in custodial prisons (in 2000 they made 55% of all imprisoned foreigners, in 2012 only one third). Presidential amnesty reduced the number of foreign prisoners almost by a fifth. The share of foreigners in total prison population have risen to 8.7% (in January 2013), since they are still more frequently (in comparison with Czech nationals) taken into custody than into prison (and amnesty influenced mainly those in prisons).

To the total number of prisoners the foreigners contributed by 8% which in the EU ranked the Czech Republic to a third of countries with the lowest share. From old-member EU countries lower share was only in Luxembourg (accompanied by the total low number of prisoners). In comparison with neighbouring countries the CR remained deeply behind Germany and Austria and, on the other hand, it came closer to the position of Poland and Slovakia (belong in the EU to the countries with the lowest share of prisoners with foreign citizenship (1–2%)). Low contributions of imprisoned foreigners in most of new member EU countries correspond with so far lower share of all foreigners in the total population.

Figure 16 Share of foreigners in the number of all prisoners in 2010–2012



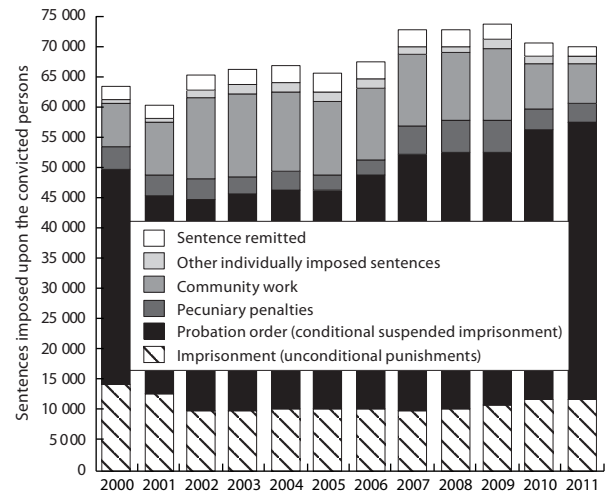
Source: Prison Service of the CR, own calculations, International Centre for Prison Studies

In the last decade significant shift took place in the structure of imprisoned foreigners in the CR by citizenship. If we abstract from the development in 2000–2002 (affected by legislative regulations of custodial prisons) then for the most important trend of the last decade we can consider weakening of the share of prisoners from the Ukraine and the Balkans in favour of the EU countries (mainly Slovakia) and Vietnam. Foreigners from the EU represented by the end of 2012 almost half of prisoners in the CR, in 2002 only one third. The share

of prisoners with Vietnamese citizenship has quadrupled for the same period. Precisely opposite was the development in case of Ukrainians whose share dropped down to one tenth. The Vietnamese and Ukrainians represent at the same time the main drive of the growth of the number of all foreigners (with permanent residence or long-term stay) in the CR, for the last decade their number increased by 105% and 80%, respectively.

Among the convicted a long-term phenomenon can be recorded, i.e. more often conditional suspended imprisonments are applied, in 2011 almost 66% persons were convicted thereby, ten years earlier only 55%. More often the community works and pecuniary penalties are applied although in 2010 their shares dropped significantly from the first time since 2000 (partly obviously in favour of conditional sentences). The falling percentage of convicted persons were imprisoned, however, this long-tern trend stopped in 2007. This fact along the growth of the number of conditional sentences (part of which will be transformed into unconditional in case of committing other offences) was the main cause of the growing number of prisoners in the last decade in the CR.

Figure 17 Numbers of convicted in the CR by more frequent types of sentences

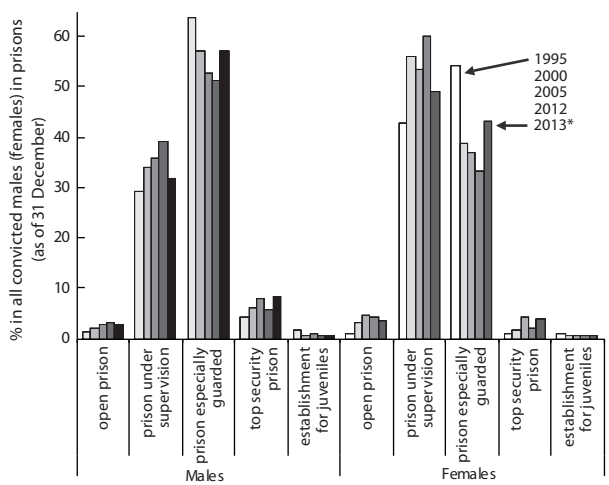


Source: Ministry of the justice of the CR, own calculations

Convicted prisoners are still most often imprisoned in medium security prisons where (at the end of 2012) almost a half of prisoners was placed. On a long-term basis, the share of convicted persons in prisons with supervision and low security (i.e. in departments with lower security) is slightly growing. Especially in the 1990's the share of convicted persons placed in departments with the strictest regime (high security) was growing, in 2002 every twelfth convicted person was put there but ten years later only every seventeenth. In special prison for juveniles almost 1% of convicted persons was placed and since 2000 their percentage showed only intangible increase.

Convicted females are, contrary to males, more often placed in low security prisons. At the end of 2012 share of women placed in lower security prisons was twice as in prisons with medium or high security. For females as well as for convicted males the same development trends apply. They are more often placed in prisons with lower level

Figure 18 Number of convicted by type of prison in the CR



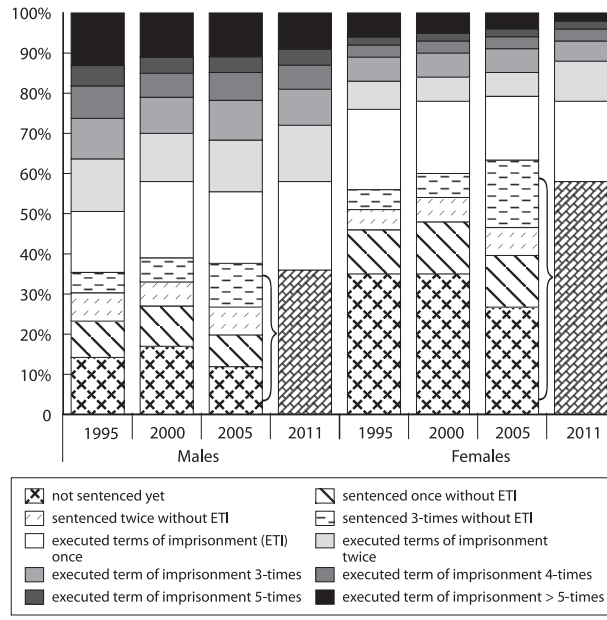
* Latest data: January 2013 (after Amnesty).
Source: Prison Service of the CR, own calculations

of security. In prisons with the highest security bigger percentage of foreigners is placed on a long-term basis (by the end of 2012 every tenth prisoner was imprisoned there, ten years earlier every sixth prisoner). The presidential amnesty changed these trends since the majority of released came from lower security prisons (see Figure 18).

Placement of convicted persons into prison facilities with a different level of security is affected by not only capacities of prisons but mainly by the term of sentence imposed by court. On long-term basis persons with sentence from 9 to 24 months prevailed, by the end of 2012 they made 41% of all convicted prisoners. Until 2005 share of convicted persons with unsuspended sentence up to 9 moths (often referred to females) increased, later these short sentences were imposed by court less often, obviously in favour of unconditional sentences (between the years 2005 and 2011 the number of probation orders increased from 36 thousand up to 46 thousand). Long stability is, on the contrary, attributed to the percentage of convicted perpetrators of very serious crimes (with the imposed sentence 7 and more years). By the end of 2012 they made one eighth of the convicted, difference between sexes were not surprisingly big (for males 12.4% and for females 10.3%). The presidential amnesty lead to significant shift in structure of prisoners by term of sentence. Almost all persons with sentence from up to 12 months were released so the share of prisoners with longer sentence have risen (see Figure 20).

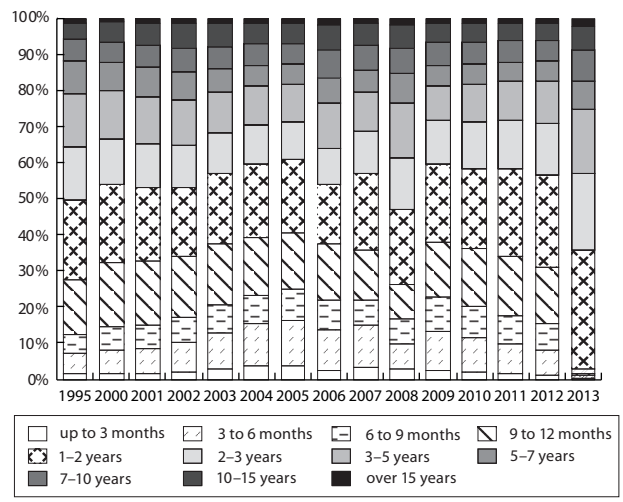
Convicted prisoners were in 2011 of the average age of 37 years still by four years younger than the total Czech population, the difference, however, was reduced for the last decade by two years. Half of convicted persons are of the age 25–39, the age difference between sexes are small. In relation to the total Czech population in 2011 the biggest number

Figure 19 Structure of convicted prisoners in the CR by previous sentences (as of 31 December)



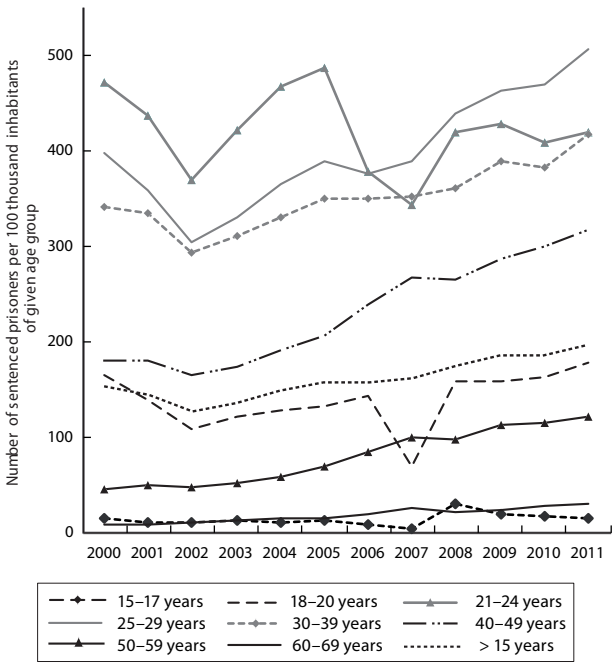
Source: Prison Service of the CR, own calculations

Figure 20 Structure of convicted persons in the CR by the term of sentence (as of 31 December)*



* Latest data: January 2013 (after Amnesty).
Source: Prison Service of the CR, own calculations

Figure 21 Number of convicted persons in prison per 100 thousand inhabitants by age groups in the CR (as of 31 December)

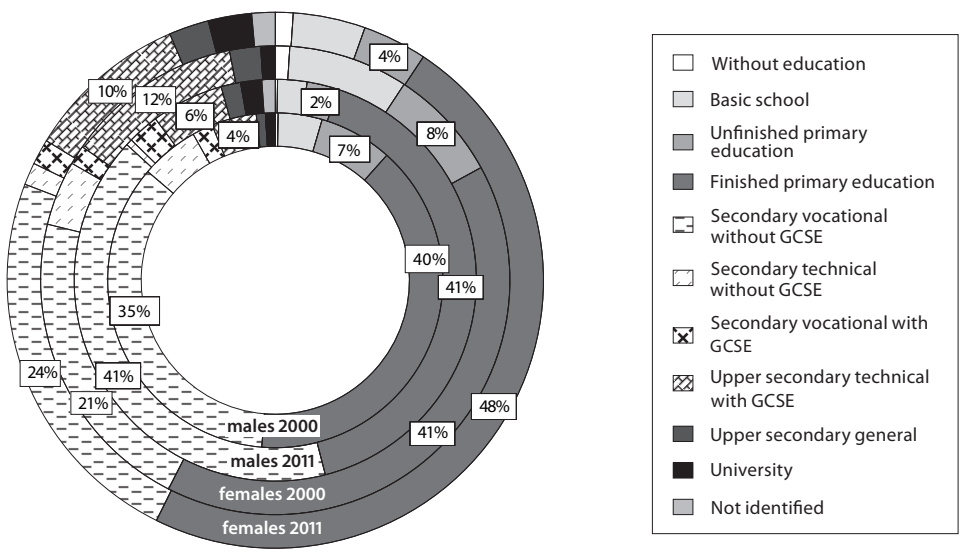


Source: Prison Service of the CR, own calculations

of convicted prisoners are in the age group 25–29 (every two hundredth persons was prisoner). Except for the group of twenty year old persons, compared to 2000 the probability of "imprisonment" in all main age groups increased, most for the people aged 40–49). Bigger growth can be attributed to the fact that certain part of convicted persons of the middle age return to prisons as criminal repeaters.

Probability to become convicted prisoners in the Czech Republic falls sharply with the level of the highest attained education. Among persons aged 15 and more with unfinished basic education or special education was in 2011 every fiftieth person a prisoner, in case of university graduates the ratio was 1 : 3000. Level of education of convicted females differed from males, at least secondary school (leaving exam passed) each sixth convicted woman, while in case of men only each ninth. Among the convicted women was, on the contrary, bigger rep-

Figure 22 Comparison of all prisoners in the CR* by sex and the highest attained education (as of 31 December)



* In 2000 only convicted prisoners, in 2011 prisoners in total (i.e. including persons in custodial prisons).
Source: Prison Service of the CR, own calculations

resentation of persons with unfinished basic education. In 2011 46% of convicted males attained primary education at maximum and for females it was 57%. Between the years 2000 and 2011 in compliance with overall social trends the educational level of prisoners slightly increased be it especially in case of males for which the share of convicted persons with maximum primary education fell by 5 p.p. Share of university graduates among the convicted prisoners doubled although at the end of 2011 it did not reach 2%.

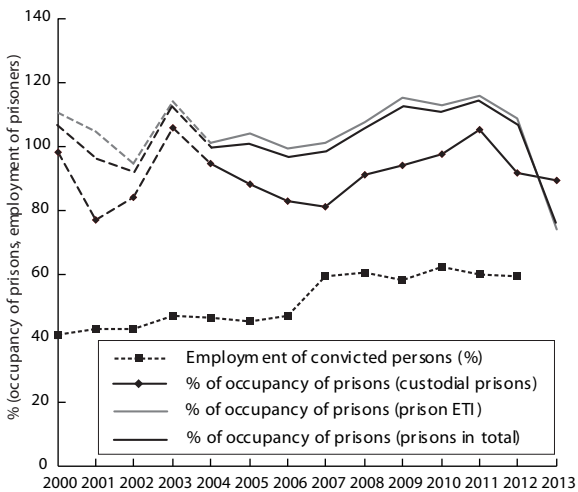
Real employment rate of convicted prisoners[14] has been increasing on long-term basis, but in recent years this positive development have ceased (see Figure 23). In 2012 it reached 59%, but ten years ago it was only around 40%. In relation to the total number of convicted the share of working prisoners has been increasing at the same period more slowly (from 36% to 46%) since permanently falling proportion of convicted persons was included into the employment records. Possibility of employment is related to the level security in prisons as well as the level of application of re-socialization programmes – usually it is higher for prisoners placed in establishments with lower security.

6.2 Prison occupancy level

Increase in the number of convicted was reflected in the growing prison occupancy level. Applying the limit 4 m^2 per person the number of sentenced prisoners exceeded available capacity in the CR as early as in 2008, in remand prisons this situation occurred in 2011. By the end of May 2012 the occupancy of capacities in remand prisons attained 102%, in prisons for sentenced persons 115%. In three quarters of all prisons in the CR the occupancy level exceeded 100% and in every fifth prison 130%. Overcrowding of capacities is recorded for big prisons and facilities with lower or medium security. This problem would have aggravated if more that 6 thousand persons who have not started to service their sentence arrived. Faster increase of overcrowding was partly prevented by regular increase of accommodation capacities which have been extended by one tenth since 2005. New prisons in the CR, however, are not built on the greenfields but often some buildings are reconstructed which have lost their original purpose (often former military quarters). At the beginning of 2012 new female prison near *Prague (Velké Přílepy)* was put into operation which can be perceived as a response to the growing number of sentenced women in recent years.

The presidential amnesty declared at the beginning of 2013 released more than a quarter of all prisoners which resulted in one-shot significant decrease in occu-

Figure 23 Occupancy level in custody and imprisonment in the CR



Note 1: Data on occupancy level in 2000–4 are not fully comparable due to unequal space limit per prisoner.

Note 2: ETI = execution of terms of imprisonment. Latest data: January 2013 (after Amnesty).

Note 3: Percentage of the occupancy level (as of 31 December) expresses the relationship between the number of prisoners (in all types of prisons including prison hospitals and detention facilities) and accommodation capacity (limit is 4 m^2/person); data from the period 2000–2004 are not fully comparable due to the influence of different space limit (3.5 m^2/person in 2000 and 2001, 4 m^2/person (year. 2002), and 4.5 m^2/person (year 2003).

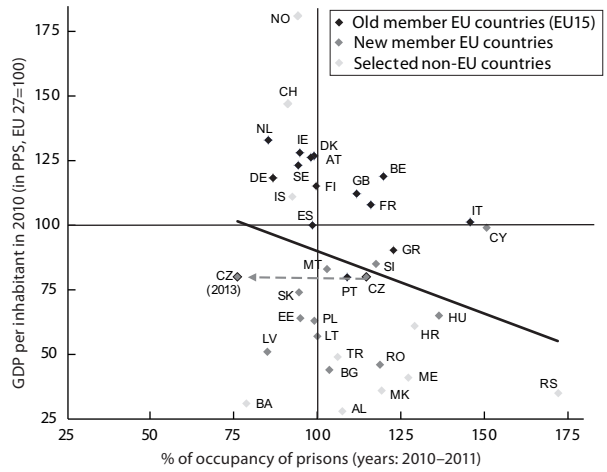
Source: Prison Service of the CR, own calculations

[14] Employment rate is expressed as the share of working people serving their sentence of imprisonment in total number of sentenced persons able to work. Convicted persons may work in internal regular operation of prison, can carry out own manufacture, can work in shops of the Centre of economic activity, at businesses or in educational and therapeutic programmes.

pancy rate. It decreased from 106% at the end of December 2012 to 76% a month later. Its reduction was evident also in remand prisons which was, however, caused by natural flows of convicted persons in the second half of 2012 rather than by amnesty (see Figure 23). The amnesty was predominantly aimed at convicted persons with the short term of sentence so we witnessed only a slight reduction in occupancy rate in prisons specialized on severe crime. At the end of January 2013 almost one fifth of all prisons for sentenced persons had occupancy between 95% and 107% on the other hand one half of prisons achieved low rate (between 40–65%). Significant decrease in occupancy rates also modified territorial structure of prison establishments in the CR. Newly opened female prison was closed and two projects aimed at transformation of former refugee camps into new prisons will be cancelled.

In international comparison the occupancy level of prisons we have to take into account possible differences in space standards (mainly the size of cells) which mainly in the countries with lower economic level may not be strictly applied. Overcrowded prisons in the CR is not in context with the EU countries anything special. However, it appears more often in new member countries. Overcrowded prisons with higher or comparable occupancy level than in the Czech Republic were observed in the period from 2010 to 2011 in one third of old EU member countries mainly due to high share of foreigners among prisoners. In comparison with all our neighbours the occupancy level of prisons was highest in the Czech Republic. On the other hand, lower occupancy rate in prisons is typical only of six European countries (out of 36 of the assessed) – from countries with big population it referred only to Germany and the Netherlands. Percentage of occupancy level of prison capacities to a certain extend depend on total economic level mainly in old EU member countries. In countries which joined the EU after 2003 there exist big disparities in the occupancy level of prisons. Their relationship with the GDP level per head or with the share of government expenditures on security and public order is not obvious.

Figure 24 Occupancy level of prisons (%) and GDP per capita (in PPS) in selected European countries (2010–2011)



Note: Names and abbreviations of countries out of EU: Albany (AL), Bosnia and Herzegovina (BA), Monte Negro (ME), Croatia (HR), Iceland (IS), Macedonia (MK), Norway (NO), Republic of Serbia (RS), Switzerland (CH), Turkey (TR).
Source: Eurostat, International Centre for Prison Studies <http://www.prisonstudies.org/info/worldbrief/wpb_country.php?country=158>

The current position of the Czech Republic within EU improved due to amnesty significantly in terms of occupancy rate (see Figure 24), but still remained unfavourable as regards total rate of imprisonment of population (see Figure 12).

CONCLUSION

Long-term slight drop of total registered crime in the CR was reflected also in government expenditures on public order and security which during the last decades were lagging behind the nominal growth of GDP. The exception formed only expenses on fire protection whose faster growth was connected with not falling frequency of fires and also higher expenditures on preventive measures related to the occurrence of devastating natural disasters in the last years. Nevertheless in the context of following economic

recession total government expenditures on public order and security were in 2011 severely reduced (by tenth) especially on police and fire-protection services. In the context of the EU countries, government expenditures on public order and security (expressed as % to GDP) in the CR (similarly as in majority of new EU members countries) still belongs to slightly above-average. This happened despite the fact that in twenty member countries – mainly in the south of Europe – the expenses expressed as above recorded a moderate increase between 2000 and 2010.

In 2011 in the CR y-o-y increase of registered crime (+1.2%) was recorded due to the growing frequency of the acts of violence (+7%), sexual offences (+15%) and burglaries (+2%). This was not an accidental deviation since in all these categories of offences a slight increase has been registered as early as since 2009 (for acts of violence since 2010). In the last 2–3 years the frequency of offences committed especially by criminal repeaters (e.g. breaking the peace, drug crimes, perverting the course of justice or desertion) is also growing. The last mentioned act shows also certain dependence on economic cycle.

Intensity of crime similarly like in other countries also in CR shows significant regional disparities. High crime intensities on long-term basis survive in big cities (*Prague* and *Ostrava*), almost in the whole area of *Ústecký* region and western part of *Liberecký* region, wider surroundings of Prague and selectively in some other near-border areas (*Chebsko, Tachovsko, Břeclavsko*). The other way round, relatively most safe area can be considered the southern part of Eastern of Bohemia, most area of *Vysočina* region and rural submontane borderland area of East Moravia. Intensity of crime differs also by various types of criminal activity – economic crime and small thefts flourish in big cities, offences against morality and acts of violence are more often registered in border areas. In the last five years the crime increased especially in the *Moravskoslezský* region. The above-mentioned disparities of registered crime correspond also with subjective perception security by the population of these localities.

The importance of quality views then grows mainly in attempts for international comparison where traditional "hard" data on crime hit different legislation and practice even in geographically close EU countries. Social pathology and criminal legislation reflect into the frequency and structure of prison population where significant selectivity by sex, education, age or previous criminal history is obvious. The other way round, from the aspect of citizenships no selectiveness in the CR was confirmed, however, obvious are changes in the structure of imprisoned foreigners (weakening of the share of prisoners from the Ukraine and the Balkans in favour of the EU countries – mainly Slovakia – and in addition also from Vietnam). Increasing number of prisoners in the CR (obvious from 2008) and in most of European countries contributes negatively to occupancy of prison capacities which raises questions how to sustain funding of the system especially in the period of total economic slump.

The presidential amnesty at the beginning of 2013 released more than a quarter of all prisoners which resulted in one-shot significant decrease in occupancy rate (mainly in prisons with low security). Nevertheless one fifth of all prisons for sentenced persons had still occupancy between 95% and 107% significant decrease in occupancy rates also modified territorial structure of prison establishments in the CR. The current position of the Czech Republic within EU improved due to amnesty significantly in terms of occupancy rate, but still remained unfavourable as regards total rate of imprisonment of population.

In near future moderate increase of "prison population" in the CR could be expected. Almost two-thirds of sentenced persons (before amnesty) had been imprisoned repeatedly. So it is very probable that significant portion of released person will return to prisons within several months. That can be assumed also on the basis of experience of vast amnesty at the beginning of 90´s which resulted in a return of one half of released persons to prisons within two years after their amnesty. Almost 6.5 thousand released prisoners in January 2013 may have negative effect on criminality, homelessness or unemployment. The presidential amnesty was also applied not only on imprisoned but also on persons convicted to alternative sentences (i.e. probation order less than two years, community work, house arrest). It is assumed that only amnesty on probation will aply on almost 15 thousand persons. This measure will probably delay

expected increase of imprisoned people since one of the main factors explaining recent gradual increase of prison population is recidivism of minor criminal acts.

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Development Intensity of four Prominent Economies[1]

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Abstract

The paper offers answers to one of the typical problems of economic theory – how it is practically possible to measure and interpret the quality of economic time series at all economic levels. At the macroeconomic level, the task is solved by weighted geometric aggregation of input factors (labor and capital) into a summary input factor (SIF) – the method is similar to the Cobb-Douglas production function. The paper shows differences between our approach and the approach of growth accounting – our approach is based on more general conditions and covers not only situations of growth of economic indicators but also situations of their decline or stagnation. The approach also allows for distinguishing the compensation of input factors. Therefore, the methodology presented in the paper can be used in many practical applications; for instance, it enables us to clearly calculate intensive and extensive parameters of economic growth.

Keywords

Aggregate production function, summary input factor, dynamic indicators, economic growth, intensive and extensive factors of change of indicators

JEL code

C22, C43

INTRODUCTION

The way a production growth is achieved at all levels of economy has been one of the key economic questions. Generally speaking (e.g. Wawrosz, 2012, p. 54), growth may result from either intensive or extensive factors, or the combination thereof, as appropriate. The development trajectory, which relies more on intensive development factors – as expected within the knowledge society, is considered to be superior. The extensive trajectory is a less preferred one, which expands the scope of production, while preserving the same production method. If both extensive and intensive factors contribute to the output development, it is worth quantifying their respective shares. The quantification is normally performed with the use of a growth accounting formula (Mihola, 2007a, Mihola, 2007b, Hájek, 2009, Cyhelský, 2012), which; however, has certain deficiencies and only allows to express the impact shares for the production growth, on condition of positive impact of both intensive and extensive factors. Our calculation method has thus been modified to ensure that it is sufficiently accurate for any growth rates of all algorithm values. The proposed solution can express the effect of intensive factors for both growing and declining

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product, including the stagnation thereof, whereas it also addresses potential compensation of extensive and intensive factors, as well as corresponding effect of both factors on the production growth or decline.

Following up on (Hájek, 2009) and (Cyhelský, 2012), the objective of this paper is to elaborate the methodology and illustrate its application to the international comparison of the development quality for the EU-15, in the United States, China and Russia for the period of ten and fifty years. While growth accounting assumes the determination of the labor/capital growth rate weights for each subject under review within each assessed year, we propose a simplification regarding the selection of these weights in this paper in terms of the sensitivity analysis and interpretation analysis of real isoquants of selected values.

1 THEORETICAL BACKGROUND

The basic shape of the national economy aggregate production function (Cyhelský, 2012, p. 38, statement (27)) or (Hájek, 2009, p. 741, statement (2)) is given by the plain multiplicative (geometrical) relation that expresses the product Y as the product of the summary productivity of factors SPF[4] and the summary input factor SIF:

$$Y = SPF \times SIF. \tag{1}$$

The national economy aggregate production function is characteristic by the fact that the value of SPF and SIF is given by the specific mix of the production types, applied technology, production efficiency and distribution of such production. Therefore, the specific value of SPF at this level is affected by the SIF structure. The determination of the level and development of SPF/SIF is the subject matter of the static or dynamic analysis. On a micro level, the production function of a specific product is given by the specific technology, which assigns specific efficiency to certain consumption of the given production factor. This is one of the reasons why it is convenient to use the polynomial function for the modeling of this product production function, as it generally has both degressive and progressive part.

The summary input factor SIF (Cyhelský, 2012, p. 38, statement (26)) is obtained as the weighted geometrical aggregation of the two[5] basic factors of production, i.e. labor L[6] and capital K. Therefore, we actually derive from the production function with technical progress.[7]

$$SIF = L^{\alpha} \times K^{(1-\alpha)}. \tag{2}$$

This function has constant returns to scale (Soukup, 2010, p. 460), because, as the sum of the weights, i.e. function exponents, equals to 1, by increasing each of the production factors t-times, the SIF will also increase t-times.

$$t.SIF = (t \times L)^{\alpha} (t \times K)^{(1-\alpha)}. \tag{3}$$

If we substitute SIF in (1) by its expression in (2), we will get:

$$Y = SPF \times L^{\alpha} \times K^{(1-\alpha)}. \tag{4}$$

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[4] Robert M. Solow (see Solow, 1957) examines the steady state growth, under which the growth rate of capital and labor equalize. The production growth per capita is then subject to technical progress, which is seen as an exogenous factor here. Further elaboration of the idea has revealed that it is not just technical progress, but rather the summary effect of all intensive growth factors.

[5] In the Czech Republic, the issue of multi-factor production function KLEM is examined by, for example Klacek (2008).

[6] In this paper, we will not examine the measuring methods of L or K in detail. The range of definition for all used values results from the range of definition for labor and capital $L > 0$ and $K > 0$.

[7] The comprehensive multiplication production study with the factors of labor, capital, and technical progress is mentioned in (Barro, 1995, p. 29); this is the Cobb-Douglas production function $Y = A \times K^{\alpha} \times L^{(1-\alpha)}$. The study also comprises the comparison with the proposals of Leontief $Y = F(K,L) = \min(AK,BL)$ of 1941; Harod of 1939; Domar of 1946; Solow of 1969; and many others. With regard to the Czech Republic, it is possible to refer to, for example, article by Hájková (2007).

Special form of the production function of neoclassical model of economic growth according to (Solow, 1957, p. 39) $Y = \kappa \times f(K, L)$, where κ stands for the SPF and the function $f(K, L)$ is an aggregate Cobb-Douglas production function. The fact that Solow understood the level of the used technology κ much more widely that just as a level of technology can be corroborated by his statement (Solow, 1957, p. 312) "The term technical change is used as a short-hand expression of any kind of shift in the production function. Thus slowdowns, speed-ups, improvements in the education of the labor force, will appear as technical change."

Since the SPF is a qualitative indicator, its change will determine whether the function (4) would have constant returns to scale or not. In case the SPF does not change and L and K increase t-times, it will be a purely extensive development (growth) corresponding to constant returns to scale. In case the growth of product Y is achieved solely as a result of changes in the SPF, it will be a purely extensive growth. For the purpose of this classification, it is more useful to dynamize the equations of the given production functions.

The aggregation method for the factors of production in a static task fully determines the aggregation method in a dynamic task. The statement (1) may easily be converted to the dynamic version of an aggregate production function expressed with the use of indices:

$$I(Y) = I(SPF) \times I(SIF), \tag{5}$$

or with the use of growth rates:[8]

$$G(Y) = \{[G(SPF) + 1] \times [G(SIF) + 1]\} - 1. \tag{6}$$

In case $I(SPF) = 1$ and $I(Y) = I(SIF) > 1$, it is a purely extensive growth. The same may be achieved using the growth rates. In case $G(SPF) = 0$ and $G(Y) = G(SIF) > 0$, it is a purely extensive growth. If both indices were greater than or equal to 1, i.e. $I(SPF) = I(SIF) > 1$, then $I(Y) = I^2(SPF) = I^2(SIF)$, which represents the so-called intensively-extensive growth. Detailed classification of all basic types of development and proposal of values of the corresponding dynamic parameters are addressed in paper Mihola (2007, p. 123).

Similarly, it is also possible to convert statement (2) into a dynamic version:

$$I(SIF) = I^{\alpha}(L) \times I^{(1-\alpha)}(K), \tag{7}$$

whereas the following applies for the growth rates:

$$G(SIF) = \{[G(L) + 1]^{\alpha} \times [G(K) + 1]^{(1-\alpha)}\} - 1. \tag{8}$$

Furthermore, we could provide an analogous typology of the SIF development for these two relations, based on the impact of labor/capital development on such development.

The isoquants of permanent production Y that correspond to statement (1) and isoquants of permanent change of production I(Y) that correspond to statement (3) are equilateral hyperbolas with c. e. of substitution 1, i.e. with variable marginal rate of substitution.

The isoquants of permanent SIF that correspond to statement (2) and isoquants of the permanent change of the summary input factor I(SIF) that correspond to statement (7) are also equilateral hyperbolas with c. e. of substitution 1; however, only if $\alpha = 0.5$. The marginal rate of substitution would only be constant on linear isoquants, which does not reflect reality in case of substitution of labor and capital. For example, in case of a high level of substitution of labor by technology, it will be necessary to use increasing amounts of capital to maintain the same SIF if the substitution intensifies.

In both cases, the hyperbolic isoquants that do not intersect the axes correspond to real economy, because neither of the values L, K, SIF, or SPF may equal to zero.

[8] The SPF growth rate, i.e. G(SPF), was used by Denison (1967, p. 15), for example, for the purpose of an international comparison of 9 developed countries.

If we substitute I(SIF) in (5) by its expression in (7), we will get a dynamic aggregate production function:

$$I(Y) = I(SPF) \times I^{\alpha}(L) \times I^{(1-\alpha)}(K). \quad (9)$$

After using logarithmic calculation, it is possible to get from (9) the following statement after introducing the growth rates:

$$\ln[G(Y) + 1] = \ln[G(SPF) + 1] + \alpha \times \ln[G(L) + 1] + (1 - \alpha) \times \ln[G(K) + 1]. \quad (10)$$

For small growth rates of up to ±5%, the following statement applies sufficiently accurately:[9]

$$\ln[G(A) + 1] \approx G(A). \quad (11)$$

By utilizing this approximate relation, it is possible to modify statement (10) as follows:

$$G(Y) = G(SPF) + \alpha \times G(L) + (1 - \alpha) \times G(K). \quad (12)$$

This is the basic equation of growth accounting.[10] It is apparent from the construction that when using the initial multiplicative aggregate production function (9) for higher change rates, it is necessary to use the precise statement (10).

2 DYNAMIC PARAMETERS OF INTENSITY AND EXTENSITY

The basic equation of growth accounting (12) is usually used to calculate a residual value, i.e. growth rate G(SPF). We will certainly get an accurate result for higher growth rates as well, if we first determine G(SIF) from statement (8) and calculate G(SPF) using statement (13) that is based on statement (6).

$$G(SPF) = \frac{G(Y) + 1}{G(SIF) + 1} - 1. \quad (13)$$

Statement (12) is also used to calculate the effect of the SPF development, G(L) development, and G(K) development, always linked to the development of G(Y). This is usually performed by dividing statement (12) by the value G(Y), whereas each of the three terms indicates the relevant effect share. However, this method may only be applied in case it is a production growth caused by positive effects of all three factors under review.

The effects of the SPF development, i.e. intensive factors, were derived for all types of development in Mihola (2007a, pp. 123 and 124).

The dynamic intensity parameter is given by the relation:

$$i = \frac{\ln I(SPF)}{|\ln I(SPF)| + |\ln I(SIF)|}. \quad (14)$$

And the dynamic extensity parameter is given by the following relation:

$$e = \frac{\ln I(SIF)}{|\ln I(SPF)| + |\ln I(SIF)|}. \quad (15)$$

To show the entire dynamic space of the development quality and ensure transparent displaying of development trajectories, it is convenient to use Figure 1, which has I(SIF) or G(SIF) on the *x*-axis and I(SPF) or G(SPF) on the *y*-axis. In order to ensure comprehensive display of this space,[11] it is possible to

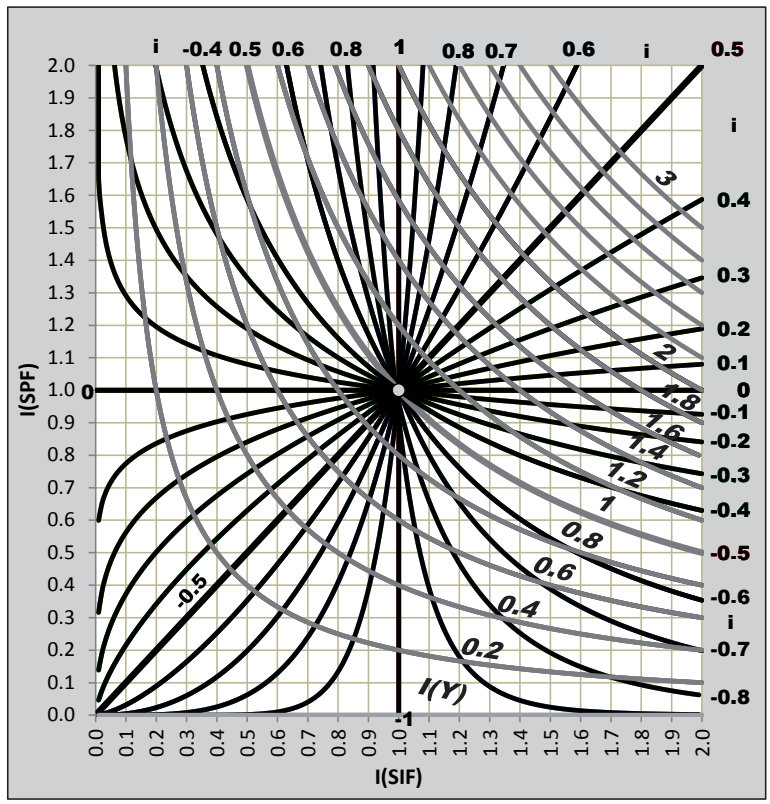
[9] When G(A) ±5% , the error equals to 0.12 p. b. – i.e. 2.5% of the value.

[10] The calculation of the aggregate productivity of factors using this relation is addressed by a number of studies, e.g. OECD (2003), OECD (2004). In terms of Czech authors, see, for example, Hurník (2005), Dybczak (2006), Hájek (2006), Ministry of Finance (2009); in Slovakia, see Zimková (2007).

[11] For spatial display, see Mihola (2007a , pp. 126 and 127).

select a wide range of definition for index (I(SIF), I(SPF)) from 0 to 2, which corresponds to the range of definition from –1 to 1 for the growth rates.[12] Thanks to the relation (5) or (6), it is also possible to plot the hyperbolic isoquants I(Y) or G (Y), as appropriate, in the chart. The zero-growth isoquant, where I(Y) = 1 or G(Y) = 0, goes through the center of the coordinate system – i.e. point [1,1]. This hyperbolic isoquant is characterized by absolute compensation of intensive and extensive development factors, where either i = 0.5 and e = –0.5 or i = –0.5 and e = 0.5. The shapes of the isoquants for development dynamics in Figure 1 depend on the weight α.

Figure 1 Range of the development dynamics quality



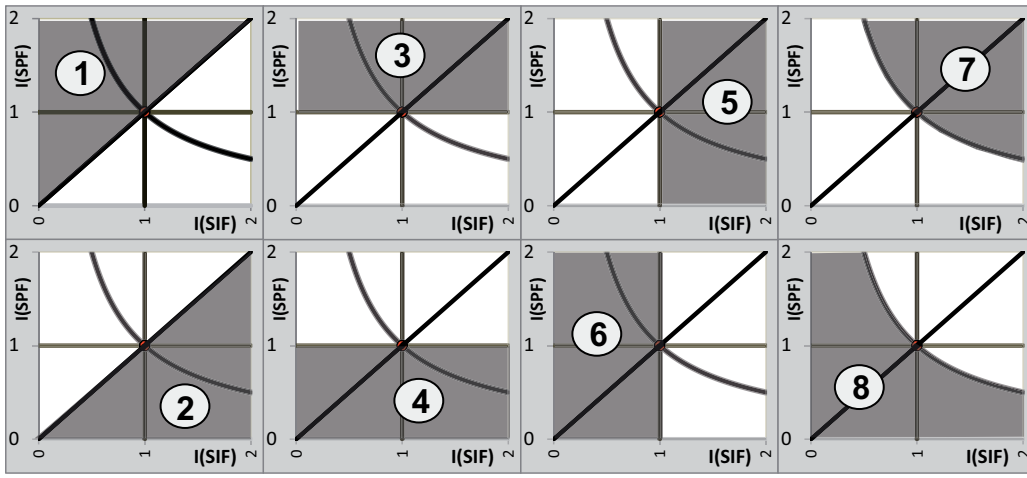
Source: Own calculations

In order to illustrate the matter, only such range is selected in practical application, in which the analyzed data fluctuate. Most isoquants will then appear to be in the form of abscissae and not curves.

Based on the location of the point within the respective combination of zones, it is possible to unambiguously characterize the development of the analyzed unit. The main qualitatively different zones are shown on the chart below, consisting of 8 ranges of the development dynamics quality (Figure 2). The described zone is always shown in grey color and identified with a number. Each two graphs located on the top of each other show zones that complete each other.

[12] Such range of definition makes it possible to model the decline of inputs or outputs to zero as well as their increase by up to 100%.

Figure 2 Qualitative zones within the development dynamics range



Characteristics of the zones:
Zone 1: i ≥ e; intensive factors exceed or equal to (within the diagonal zone border) extensive factors;
Zone 2: i ≤ e; extensive factors exceed or equal to (within the diagonal zone border) intensive factors;
Zone 3: i ≥ 0; intensive factors are positive or equal to zero (on the horizontal zone border);
Zone 4: i ≤ 0; intensive factors are negative or equal to zero (on the horizontal zone border);
Zone 5: e ≥ 0; extensive factors are positive or equal to zero (on the vertical zone border);
Zone 6: e ≤ 0; extensive factors are negative or equal to zero (on the vertical zone border);
Zone 7: I(Y) ≥ 1 i.e. G(Y) ≥ 0; product increases or stagnates (on the hyperbolic zone border);
Zone 8: I(Y) ≤ 1 i.e. G(Y) ≤ 0; product decreases or stagnates (on the hyperbolic zone border).

Source: Own calculations

Each specific point is always located within several zones concurrently. For example, if a point is located within the intersection of zones no. 1, 6, and 7, it means the product growth results from the predominant effect of intensive factors, which are partly compensated by extensive factors.

3 DYNAMIC SPACE OF THE SIF STRUCTURE DEVELOPMENT

The SIF structure development range relies on similar principles as the development dynamics quality range. In this case, I(L) or G(L) is shown on the *x*-axis, while I(K) or G(K) is shown on the *y*-axis. Since the formula (7) or (8) applies, we may also plot the isoquants I(SIF) and G(SIF) in this space. Using analogy, we can also define formulas for the dynamic parameter effect of the development of labor L on the SIF development for the formulas of dynamic intensity/extensity parameters:

$$l = \frac{\alpha \times \ln \mathrm{I(L)}}{\alpha \times |\ln \mathrm{I(L)}| + (1 - \alpha) \times |\ln \mathrm{I(K)}|}. \tag{16}$$

And the effect of the development of capital K on the SIF development:

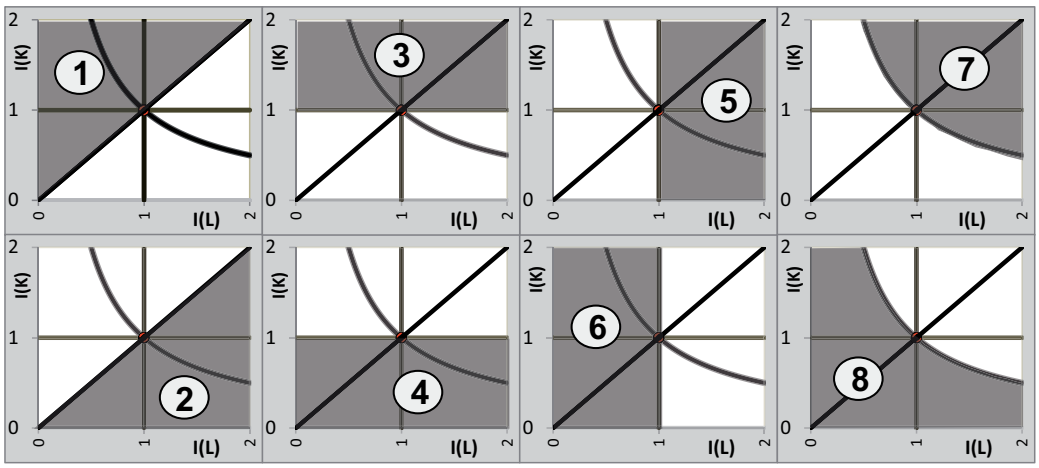
$$k = \frac{(1 - \alpha) \times \ln \mathrm{I(K)}}{\alpha \times |\ln \mathrm{I(L)}| + (1 - \alpha) \times |\ln \mathrm{I(K)}|}. \tag{17}$$

In this space, it is also possible to plot the isoquants of constant change in the capital/labor ratio I(K/L) or G(K/L), since the following formula applies:

$$\mathrm{I(K/L)} = \mathrm{I(K)} / \mathrm{I(L)}. \tag{18}$$

This space depends on the selection of the weight α. It is symmetrical to the quadrant I axis for α = 0.5 only. Furthermore, it is also possible to define qualitative zones in this space, as shown in Figure 3.

Figure 3 Qualitative zones within the SIF structure range



Characteristics of the zones:
Zone 1: $k \geq l$; capital increases faster than or at the same rate (at the zone border) as labor; the capital/labor ratio increases; the substation of labor by capital takes place or remains constant (at the zone border);
Zone 2: $k \leq l$; labor increases faster than or at the same rate (at the zone border) as capital; the capital/labor ratio decreases or remains constant (at the diagonal zone border);
Zone 3: $k \geq 0$; capital increases or stagnates (at the horizontal zone border);
Zone 4: $k \leq 0$; capital decreases or stagnates (at the horizontal zone border);
Zone 5: $l \geq 0$; labor increases or stagnates (at the vertical zone border);
Zone 6: $l \leq 0$; labor decreases or stagnates (at the vertical zone border);
Zone 7: I(SIF) ≥ 1 i.e. G(SIF) ≥ 0; the summary input factor increases or stagnates (at the hyperbolic zone border);
Zone 8: I(SIF) ≤ 1 i.e. G(SIF) ≤ 0; the summary input factor decreases or stagnates (at the hyperbolic zone border).

Source: Own calculations

In case K and L increase at the same rate, the capital/labor ratio will not change either.

$$I(L) = I(K) = I(SIF). \tag{19}$$

In this case, if we substitute in statement (16):

$$l = \alpha. \tag{20}$$

And at the same time in statement (17):

$$k = (1 - \alpha). \tag{21}$$

Then the same effect of the development of both factors, i.e. L and K on the development of the SIF should correspond to the same share I(L) and I(K), i.e. 50%. Due to (20) and (21), the equality t $l = k$ only applies for α = 0.5.

In case of compensation of both factors, where I(SIF) = 1, i.e. G(SIF) = 0, also the statements (20) and (21) apply for I(L) > 1. In case I(L) < 1, it is necessary to change the sign in statements (20) and (21). Therefore, in the given case for α = 0.5, $l = 0.5$ and $k = -0.5$ or $l = -0.5$ and $k = 0.5$, which has very good

interpretation corresponding to the compensation interpretation of intensive and extensive factors within the range of the development dynamics quality (see Figure 1).

Using all 4 parameters – i.e. *i, e, l,* and *k*, it is possible to expand the typology of developments. For example, the following applies for a purely extensive development: $i = 0$, $e = 1$, $l = 0.5$ and $k = 0.5$.

4 METHODOLOGY OF INTERNATIONAL COMPARISON

The methodology derived within the previous chapters will be applied to the comparison of the development dynamics quality of the EU-15, United States, China, and Russia (Soviet Union until 1992) for the period of last fifty (1961–2011) and last ten year. At the same time, relevant total data for these four economic units will be calculated. The result will be shown within a suitable segment of the development dynamics quality and within the SIF structure development range.

The data were collected in the Statistical Annexes of European Economy, which are included in the EU prognoses, as well as in research studies and articles published in scientific journals. For the sake of credibility of the collected data, we confronted their development with the evaluation of relevant stages by different authors and organizations.

The GDP growth rate for the EU-15 region is available since 1961, similarly as for the United States – for individual years of the period. Such data are collected from the Statistical Annexes of European Economy published by the EU. With regard to China, the annual data for the period under review are available from the Chinese Statistical Annual Reports and from the National Statistical Bureau. In terms of Russia, the data starting from 1992 have been adopted from the prognoses of the International Monetary Fund (World Economic Outlook, IMF), which always specify the relevant data for the past years. The period of 1961 to 1991 relates to the former Soviet Union; however, due to its size, Russia had a predominant importance for the dynamics of the entire Soviet Union. In this sense, it is possible to use the data – with minor objections – for the assessment of the entire period under review. With regard to the Soviet Union, the product growth rates concern the real gross national product GNP; however, the dynamics in principle do not differ from the GDP dynamics. The GNP growth rates for the former Soviet Union were taken over from scientific literature and it concerns estimates, because the former Soviet Union did not publish such data. In case the annual data were missing; however, there were five-year averages available, we completed the annual data to preserve the average growth rate for the respective five-year period.

The annual employment growth rates for the EU-15 and the United States were taken from the Statistical Annexes of European Economy (EU) for the entire period under review. With regard to China, such annual data were collected in scientific articles and from the International Labor Organization ILO; the ILO also provided the data for Russia for the period of 1992–2011. With regard to the former Soviet Union, the data for the period of 1961–1991 were taken take over from scientific articles and, once again, some missing growth rates were completed to correspond to the published average annual growth rate for the respective five-year period.

The annual growth of the capital reserve for the EU-15 and the United States were taken from the Statistical Annexes of European Economy of the E for the entire period under review. With regards to methodology, the collection of the data consists in the application of the perpetual inventory method. The method subsists in adding gross investments to the capital reserve and in subtracting any capital written off, based on the estimated level of depreciation. With regard to China, the literature only mentions contribution of capital to the GDP growth – calculated as the product of the income share of capital multiplied by the capital growth rate for approximately first half of the given period. Therefore, by retroactively dividing it by the income share of capital, we get the capital reserve growth rate. With regard

[13] There is currently no integrated source of the information, whereas it is necessary to respect revisions, which modify data, on post facto basis, from time intervals of different duration.

to the second period, the capital growth rate is adopted from scientific literature, where it had been calculated using the perpetual inventory method. With regard to Russia (1992–2011), the data have been taken over from the UN study as well as the World Economic Outlook of the IMF. The capital growth rates have been, once again, derived from the contribution of capital to GDP growth. In terms of the former Soviet Union, the capital growth rates for the period of 1961–1991 were collected from scientific literature and the missing annual data were completed so that the average of the annual data corresponds to the growth rate for the respective five-year period specified in the literature. With regard to the United States, the year-to-year weights α were determined using a standard method.

The initial data for the analysis are the time series of the growth rates G(GDP), G(L) and G(K) for the period of 1961–2011. Using the formula (8) for[14] α = 0.5, the summary input factor growth rate G(SIF) has been calculated. The statement (13) was used for the purpose of calculating the growth rate of the summary productivity of factors G(SPF).

Such growth rates make it possible to calculate all four reviewed dynamic parameters of ***i***; ***e***; ***l***, and ***k***. Using statement (18), modified for the growth rates, the growth rate of the capital/labor ratio G(K/L) was calculated. The selection of the weight α only affects the range of the SIF structure. We believe that it is not necessary to prefer any of the factors of production L and K[15] when aggregating them into the SIF.[16] There is also no reason for the asymmetry of the SIF structure range, because the isoquants I(K/L) do not depend on the selection of α.

5 COMPARING THE DEVELOPMENT DYNAMICS OF INDIVIDUAL SUPERPOWERS

The initial average data, similarly as all the calculated characteristics for the entire period, are shown in Table 1 and Table 2 (for the last 10 years).

Table 1 Growth rates for output, input parameters *i*, *e*, *l*, *k* for the period of 1960–2011

1961–2011	G(Y)	G(L)	G(K)	G(SIF)	G(SPF)	G(K/L)	*i*	*e*	*l*	*k*
USA	3.1%	1.5%	2.8%	2.2%	0.9%	1.3%	30%	70%	35%	65%
EU-15	2.7%	0.4%	3.0%	1.7%	0.9%	2.6%	35%	65%	13%	87%
China	8.1%	2.2%	7.1%	4.7%	3.2%	5.0%	41%	59%	24%	76%
Russia	2.1%	0.6%	2.2%	1.4%	0.7%	1.6%	33%	67%	20%	80%

Source: Own calculations based on year-to-year growth rates of the initial data, i.e. G(Y); G(L) and G(K)

The performance of the economies under review characterizes the GDP growth rate at constant prices. China recorded the highest average year-to-year growth rate of 8.1%, followed by the United States with the growth rate of 3.1%, and the EU-15 with 2.7%. Russia[17] recorded the lowest growth rate of 2.1%. China

[14] As part of the calculations, the sensitivity analysis relating to the value of the selected weight α had also been performed. The selection within the interval of 0.5 to 0.7 for all economies did not have any significant impact on the generated results, namely on mutual proportions and ranking. If we were to reduce α below 0.4, the differences between the economies under review will start to fade.

[15] This is not even subject to the fact that namely substitution of labor by technology has been historically winning recognition; the labor/capital ratio has thus been permanently rising. This process takes place through investments, which is associated with increasing SPF in case of rational behavior. This will be expressed as a transition to isoquants with higher production.

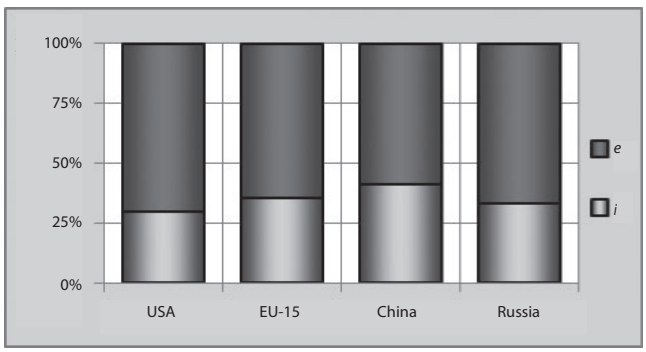
[16] One of the reasons why it does make sense to prefer one of the considered factors of production is the fact that all countries, in principle, gradually apply basically the same technical and other progress.

[17] The data for Russia – as the successor country of the Soviet Union – comprise a time series of data for the Soviet Union, transformation period after 1992, as well as for Russia; such data are also affected by the aforementioned transformation period.

has the highest growth rates for all six categories under review. In China, the highest growth rate of both labor (2.2%) and capital (7.1%) is reflected in high growth rate of the SIF (4.7%). These newly deployed factors of production are used with the highest growth rate of SPF = 3.2%, which is also reflected in the highest growth rate of the capital/labor ratio of 5.0%. The second highest growth rates of the product, labor, capital, and thereby the SIF have been recorded by the United States; however, the effectiveness growth rate measured by the SPF is the same as in the EU-15, specifically 0.9%. The EU-15 shows a significantly higher capital/labor ratio (2.6%) compared to Russia (1.6%) and the United States (1.3%). However, we should not simply assume that the United States may be on a lower technical level, as this can result from the fact that the United States had already reached the higher level prior to 1960. With the exception of the capital/labor ratio growth rate, the lowest growth rates of all the remaining categories under review were recorded in Russia. However, this was significantly affected by the collapse of the Soviet Union; therefore, we will also separately monitor the period of the past ten years within this example.

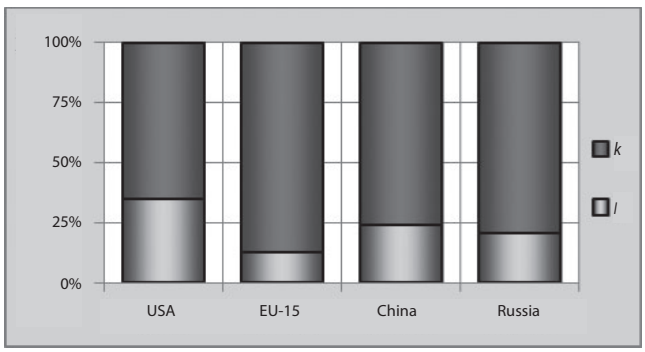
In order to compare the development dynamics quality of individual units, we will use Figure 4. It is apparent that both factors – i.e. extensive and intensive – affect the product growth. The extensive development prevails in all the economies under review. The highest intensity is recorded in China (41%), followed by the EU-15 (35%), Russia (33%), and the United States (30%). In order to compare the SIF development, we will use Figure 5. The growth of both factors under review affects the SIF growth in all the analyzed economies, whereas the impact of the capital development on the SIF development is higher in all the analyzed economies. The lowest impact of the labor development on the SIF development was recorded in the EU-15 – specifically 13%. Higher effects were recorded for Russia (20%), followed by China (24%), and the United States (35%).

Figure 4 Development intensity and extensity 1961–2011



Source: Own calculations based on year-to-year growth rates of the initial data, i.e. G(Y); G(L) and G(K)

Figure 5 SIF structure development 1961–2011



Source: Own calculations based on year-to-year growth rates of the initial data, i.e. G(Y); G(L) and G(K)

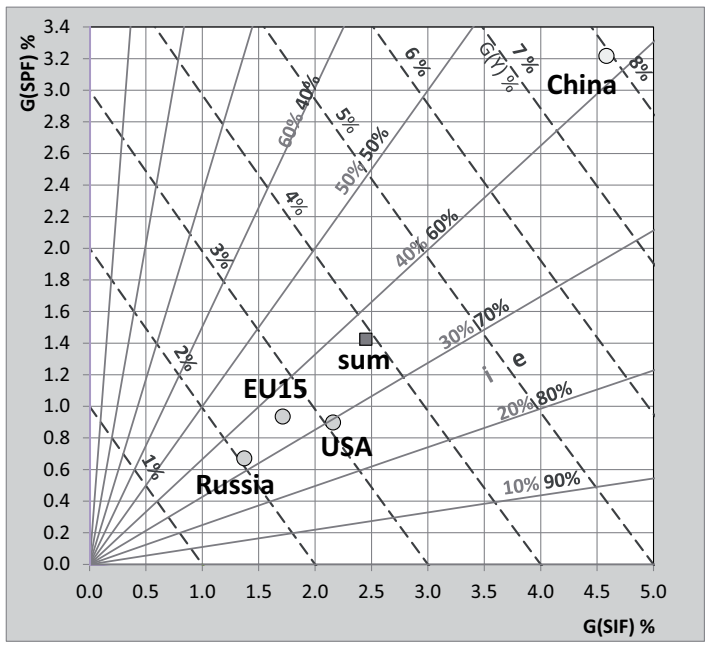
For the purpose of the comprehensive assessment of the development quality of the analyzed units, the development quality range (Figures 6 and 8) and the SIF structure development range (Figures 7 and 9) will be used. These ranges makes it possible to compare simultaneously all the above mentioned economic units in terms of all the characteristics under review.

The point corresponding to the sum (total) of all four economies under review corresponds to the SIF growth rate or nearly 2.5% and the SPF growth rate of 1.4%. The average production growth rate amounts to nearly 4%. The dominance of exten-

sive factors is also corroborated by the fact the intensity exceeds 35%, i.e. this corresponds to extensity of slightly below 65%.

The location of the sum point to the right of and above the cluster of three points representing the economies of the United States, Russia, and the EU-15 indicates significant impact of China, which experienced significantly different development than the remaining three economies. The development China appears to be the most rapid and intensive: China's point is located above the 40%-intensity level, while the remaining economies under review are within the 30% to 40%-intensity level. The development of the remaining three economies over the entire fifty-year period does not differ much. The production growth rate of the United States is slightly higher than 3%, with the EU-15 recording a modestly lower growth rate, while Russia recorded the product growth rate of slightly over 2%. Of the three economic units, the EU-15 is slightly more intensive than Russia and the United States (intensity of almost 30%).

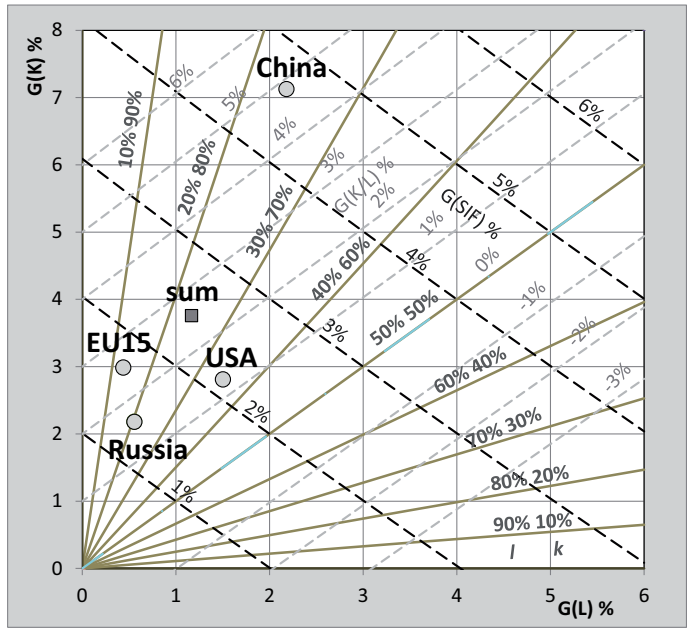
Figure 6 Comparison of the development dynamics quality (indicators G(SIF) and G(SPF)) for the period of 1961–2011



Source: Own calculations

The SIF structure development for the individual economies under review is shown in Figure 7. All the economies experience the growth of the capital/labor ratio (technology), whereas the SIF growth is affected by the labor increases as well as capital increases. The points representing the economies of the United States, Russia and the EU-15 are close together again, while the point representing China deviates to higher SIF growth rates. The effect of capital is higher in Russia (approximately 80%), with the highest level recorded in the EU-15 (nearly 90%). It is significantly lower in the United States, around 65%. The results will be different if we compare the technical substitution growth rate. China has a significantly higher rate (almost 5%), the EU-15 has the same growth rate as the total (little over 2.5%), while Russia and the United States show the value around 1.5%.

Figure 7 Comparison of the development dynamics quality (indicators G(L) and G(K)) for the period of 1961–2011



Source: Own calculations

We can similarly analyze the development in the last ten years as well. The initial and calculated data are consolidated in Table 2, once again. The table is arranged analogically to Table 1.

Table 2 Growth rates for output, input parameters *i*, *e*, *l*, *k* for the period of 2000–2011

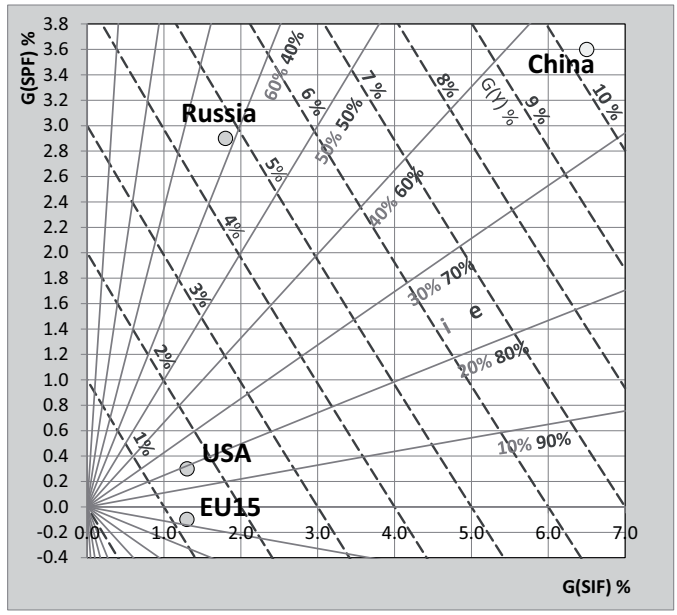
2001–2011	G(Y)	G(L)	G(K)	G(SIF)	G(SPF)	G(K/L)	*i*	*e*	*l*	*k*
USA	1.5%	0.2%	2.3%	1.3%	0.3%	2.1%	17%	83%	8%	92%
EU-15	1.2%	0.6%	2.0%	1.3%	–0.1%	1.4%	–6%	94%	23%	77%
China	10.4%	0.7%	12.3%	6.5%	3.6%	12.0%	36%	64%	6%	94%
Russia	4.7%	0.7%	2.8%	1.8%	2.9%	2.1%	62%	38%	20%	80%

Source: Own calculations based on year-to-year growth rates of the initial data, i.e. G(Y); G(L) and G(K)

The development quality of the economies under review will be compared in the same projection; however, with a slightly different section that will allow to display moderately negative SPF growth rates, which were recorded in the EU-15.

At first sight, it is clear that China still has a high product growth rate – over 10% with intensity of 36%. Russia has assumed an absolutely new role, with the product growth rate of nearly 5 % and the group-leading intensity of 60%. The SPF growth rates for China (more than 3.6%) and Russia (nearly 3%) are comparable; however, Russia has a SIF growth rate of almost 2%, opposed to China's SIF growth rate of 6.5%. The United States and the EU-15 have the same SIF growth rate of 1.3%. However, the United States recorded the SPF growth rate of 0.3%, while the EU-15 even experienced slight negative SPF growth rate of –0.1%. Consequently, the United States failed to reach intensity of 20%, while the EU-15 experienced negative intensity of –6%.

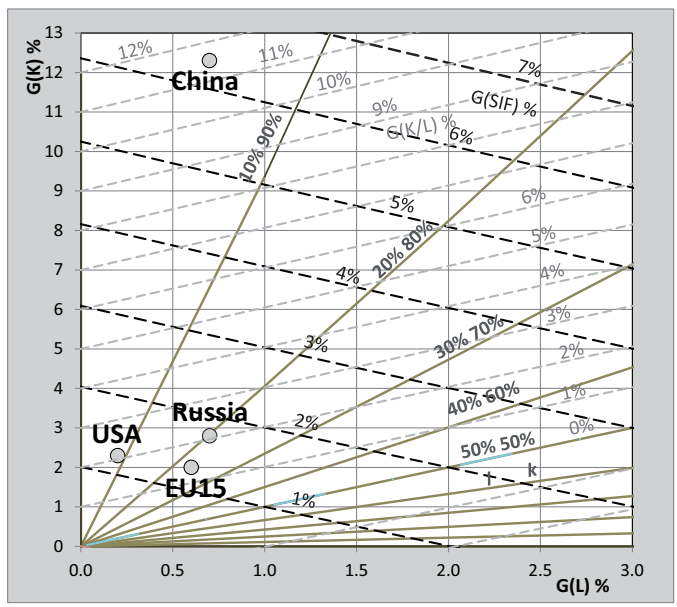
Figure 8 Comparison of the development dynamics quality (indicators G(SIF) and G(SPF))



For the period of 2001–2011.

Source: Own calculations

Figure 9 Comparison of the SIF structure development (indicators G(L) and G(K))



For the period of 2001–2011.

Source: Own calculations

As apparent from Figure 9, the SIF structure developments were less significant. The distribution of the points representing individual economies continues to be very similar, even though Russia has a somewhat different role. China continues to be far from the other economies, whereas the SIF growth rate is 2% higher, as it reached 6.5%. The impact of the capital development on the SIF development increased, amounting to nearly 95%, i.e. 2% up compared to the United States. China still has the highest capital/labor ratio growth rate of 11.5%. Furthermore, the impact of the capital increase on the SIF development prevails over the impact of the labor development.

CONCLUSION

The paper has provided a practical example of international comparison with regard to the application of intensive development factors, characteristic for the knowledge society, in the time series of fifty years. It has been demonstrated that it is possible to successfully elaborate the analysis of the development trajectory quality using the multiplicative aggregate production function, where the summary input factor can be calculated as a weighted geometrical average. The sensitivity analysis of the results has revealed that a single selection of the weights at $\alpha = 0.5$, which represents the symmetric range (space) of the SIF structure development, has not significantly modified the collected results to the extent of sensitivity of α 0.5–0.7. A single selection of α is based on the idea of a globally delayed, yet still uniform, technological and knowledge progress. The international comparison presented in the paper is only covered by a dynamic task.[18] For the desired expansion of the matter by a static task, it would be necessary to obtain absolute data about the actual values of K and L or national wealth, as appropriate, for individual countries. A static task could provide an answer to whether or not the current extensive development in the United States represents the effect of achieving high technical level in the past (prior to 1960).

The example concerning the development quality comparison for the superpowers – i.e. for the United States, China, Russia, and the EU-15 – for the period of last 50 and 10 years shows the abundance of data that can be extracted from the time series of mere 3 national economy characteristics. The analysis has revealed that China appears to be the most dynamically and intensively developing superpower. Furthermore, the development of Russia also appears to be very intensive in the past decade.

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[18] The terms "dynamic task" and "static task" are explained in Mihola (2007b, p. 448).

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Determinants of the Slovak Enterprises Profitability: Quantile Regression Approach

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Abstract

The goal of this paper is to analyze profitability of the Slovak enterprises by means of quantile regression. The analysis is based on individual data from the 2001, 2006 and 2011 financial statements of the Slovak companies. Profitability is proxied by ratio of profit/loss to total assets, and twelve covariates are used in the study, including two nominal variables: region and sector. According to the findings size, short- and long-term indebtedness, ratio of long-term assets to total assets, ratio of sales revenue to cost of sales, region and sector are the possible determinants of profitability of the companies in Slovakia. The results further suggest that the changes over time have influenced the magnitude of the effects of given variables.

Keywords

Profitability, quantile regression, Slovakia

JEL code

C51, L25

INTRODUCTION

Company's profit still remains one of the most frequently used indicators when assessing the company's performance. Profit itself has many drawbacks, and is often criticized, as it does not reflect the overall financial situation of the company.

There exist numerous sources dealing with financial performance of the firms. The authors analyzing profitability consider size (Gschwandtner, 2005), liquidity (Adams and Buckle, 2003), debt (Goddard, Tavakoli and Wilson, 2005), research and development intensity (Andries and Debackere, 2007), risk (Adams and Buckle, 2003), and managerial control (Garicano, 2000) the most important factors affecting firms' profitability (for further discussion see e. g. Nunes, Serrasqueiro and Leitao, 2010).

Most of the studies are based on sample data (Steinerowska-Streb, 2012; Asimakopoulos, Samitasand Papadogonas, 2009). In our research we use administrative data from individual financial statements of the Slovak firms provided by the Financial Directorate of the Slovak Republic. The advantage of such data is that it covers almost all enterprises in Slovakia, but the limitation subsists in the fact that only the data collected by the Financial Directorate for tax purposes can be used. We do not have data on the number of employees, which can be considered as the most significant shortcoming of the study.

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The goal of this paper is to identify determinants of the Slovak companies' profit/loss. This exploratory analysis is focused on revealing associations and relations among the net income and selected ratios. As variability of the dependent variable is very high, quantile regression is a suitable tool for analyzing the given problem. Quantile regression allows us to check whether the relationship between net income (profit or loss) and the determinants over the distribution of net income is uniform or not (Nunes, Serrasqueiro and Leitao, 2010). Hence, the results give an answer to the question whether there are differences in the magnitude of factors (estimated coefficients) among the firms with high/low profits/losses. That is to say whether for instance firms with high profits are affected by liquidity more significantly than firms with low profits.

In this exploratory study we investigate which of the usually considered potential factors (proposed by literature) significantly influence the Slovak firms' profitability. On one hand our aim is to identify which factors are significant and which are insignificant in explaining profitability. On the other hand our aim is to analyze the magnitude of significant factors (regression coefficients) at particular quantiles.

1 METHODOLOGY

1.1 Observation Units and Description of the Data

This study is based on administrative financial data from individual financial statements of the Slovak firms using the double-entry bookkeeping. The data were obtained from the Financial Directorate of the Slovak Republic for research purposes. We use data of three selected years: 2001, 2006 and 2011. Consistency of the data was checked only by comparing profit/loss values from the individual profit and loss statements, and balance sheets. Around three percent of all statements show inconsistencies (such observations were dropped from the analysis).

The original data sets include 30 053 (2001), 94 999 (2006) and 149 063 (2011) observations. Due to incompleteness of the data 11 068 (2001), 26 888 (2006) and 32 493 (2011) observations were used in the study. Observations with missing data for any of the variables described below were dropped from the analysis.

Table 1 Variables used in regression analysis

Variables	Abbr.	Measurement
Dependent		
Profitability	*roa*	Ratio of profit/loss to total assets
Independent		
Size	*siz*	Logarithm of total sales revenue
Liquidity	*liq*	Ratio of current assets to short-term debt
Short-term indebtedness	*sti*	Ratio of short-term debt to total assets
Long-term indebtedness	*lti*	Ratio of long-term debt to total assets
Days accounts receivable	*dar*	(Ratio of accounts receivable to total sales revenue) / 360
Days sales of inventory	*dsi*	(Ratio of inventory to total sales revenue) / 360
Asset to sales ratio	*asr*	Ratio of total assets to total sales revenue
Share of long-term assets	*lta*	Ratio of long-term assets to total assets
Value added index	*vai*	Ratio of sales revenue to cost of sales
Labor costs	*lab*	Ratio of labor costs to value added
Region	*reg*	Dummy variables for NUTS-2 regions: [*reference category*] Bratislava Region *regWS:* Western Slovak Region *regCS:* Central Slovak Region *regES:* Eastern Slovak Region
Sector	*sec*	Dummy variables for NACE branches: [*reference category*] primary sector: A–B branches *secS:* secondary sector: C–F branches *secT:* tertiary sector: G–P branch

Source: Own construction

1.2 Variables

Table 1 presents variables used in this study. Profitability is the dependent variable, and is given by the ratio net income (profit/loss) to total assets.

Twelve independent variables are considered in the study. The size of an enterprise is given by logarithm of total sales, liquidity is defined as ratio of current assets to short-term debt, short/long-term indebtedness is given by ratio of short/long-term debt to total assets, and the following four standard ratios are used: days accounts receivable, days sales of inventory, asset to sales ratio, and share of long-term assets. Value added index is defined as ratio of sales revenue to cost of sales, and the last ratio indicating labor intensiveness is given by labor costs to value added. Two dummy variables (region and sector) are employed to control for the specific effects of economic activity and location on profitability.

1.3 Estimation method

This study is aimed at assessing relationship between profitability and its determinants, over the distribution of profitability of the Slovak enterprises. As proposed by Nunes, Serrasqueiro and Leitao (2010), quantile conditional regression (Koenker and Bassett, 1978; Koenker and Hallock, 2001) is the most appropriate methodology for such type of a study.

Quantile regression generalizes the concept of a univariate quantile to a conditional quantile given one or more covariates (Chen, 2005). For a random variable Y with probability distribution function $F(y) = \text{Prob}(Y \leq y)$ the τ^{th} quantile of Y is defined as the inverse function $Q(\tau) = \inf\{y : F(y) \geq \tau\}$ where $0 < \tau < 1$. Considering that the τ^{th} quantile of the conditional distribution of the dependent variable (Y_i) is a linear function of the vector of the independent variables (X_i), the quantile conditional regression can be presented in the following way:

$$y_i = \alpha_\tau + \boldsymbol{\beta}_\tau \mathbf{x}_{i\cdot} + z_{\tau i}, \tag{1}$$

and

$$\mathrm{Q}_\tau\left(\mathrm{y}_\mathrm{i} \mid \boldsymbol{x}_{\mathrm{i}\cdot}\right) \equiv \inf\left\{\mathrm{y}_\mathrm{i} : \mathrm{F}_\mathrm{i}\left(\mathrm{y}_\mathrm{i} \mid \boldsymbol{x}_{\mathrm{i}\cdot}\right) \geq \tau\right\} = \alpha_\tau + \boldsymbol{\beta}_\tau \boldsymbol{x}_{\mathrm{i}\cdot}, \tag{2}$$

with the following restriction:

$$Q_\tau\left(z_{\tau i} \mid \mathbf{x}_{i\cdot}\right) = 0, \tag{3}$$

where:

y_i is i^{th} element of n-by-1 vector y of dependent variable,
$\mathbf{x}_{i\cdot}$ is i^{th} row of n-by-k matrix $\mathbf{X}$ of independent variables,
α_τ, $\boldsymbol{\beta}_\tau$ are parameters to be estimated for different values of $\tau \in (0;1)$,
$z_{\tau i}$ is the error term,
n is the number of observations,
k is the number of independent variables.

In this study we test the relationship between profitability and its determinants for the 5^{th}, 10^{th}, 25^{th}, 50^{th}, 75^{th}, 90^{th}, and 95^{th} percentiles of the distribution of probability of the Slovak enterprises. Estimation of coefficients standard errors and hypotheses tests are based on bootstrapping (Parzen, Wei and Ying, 1994). Variance inflation factor (Fox and Monette, 1992) was used for multicollinearity diagnostics. Goodness of fit diagnostics for the estimated quantile regression models is based on $R^1(\tau)$ measure (which is the analog of traditional R-squared) and the associated likelihood ratio test proposed by Koenker and Machado (1999). $R^1(\tau)$ measures the relative success of the corresponding quantile regression models at a specific quantile, i.e. $R^1(\tau)$ is a local measure of goodness of fit for a particular quantile. The full model (i.e. model with covariates) is better at the τ-quantile than the restricted model (including only an 'intercept' parameter) if the τ^{th} conditional quantile function is significantly altered by the influence of the covariates. Koenker and Machado (1999) further explore behavior of the proposed measures using

a range of artificial data. According to their findings $R^1(\tau)$ does not perform well (has low values) in case of high variability of the data (which is our case), and hence p-value of the associated likelihood ratio test will be taken into consideration as a criterion of goodness of fit for a particular quantile. In order to check for multicollinearity in the model, variance inflation factors (see Fox and Monette, 1992; Fox and Weisberg, 2011 for details regarding estimation of variance inflation factors for categorical variables) are estimated. Almost all values are close to one, which indicates very low level of multicollinearity among the variables. The variable 'dar' was strongly correlated with two other variables (which was indicated by a high value of variance inflation factor), and that is why 'dar' was dropped from the 2001 analysis.

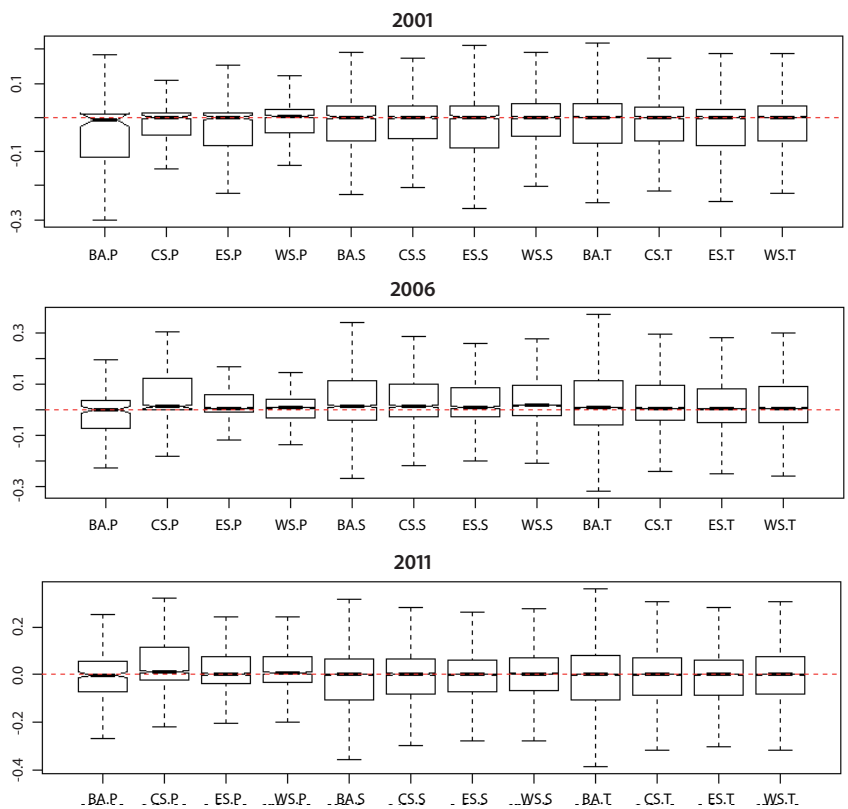
All estimations have been performed in R environment (R Core Team, 2012) using package 'quantreg' (Koenker, 2012).

2 RESULTS AND DISCUSSION

2.1 Descriptive Statistics

Figure 1 presents distribution of the dependent variable, i.e. profitability (*measured as return on assets – 'roa'*) across regions and sectors of Slovakia using notched box plots (Chambers et al., 1983). The box plots indicate that the Slovak enterprises performed in 2006 better than in 2001 and 2011, while the highest proportion of loss-making enterprises was in 2001. The median value of *'roa'* was around zero across all regions and sectors in all three periods.

Figure 1 Distribution of *'roa'* across regions and sectors in 2001, 2006 and 2011

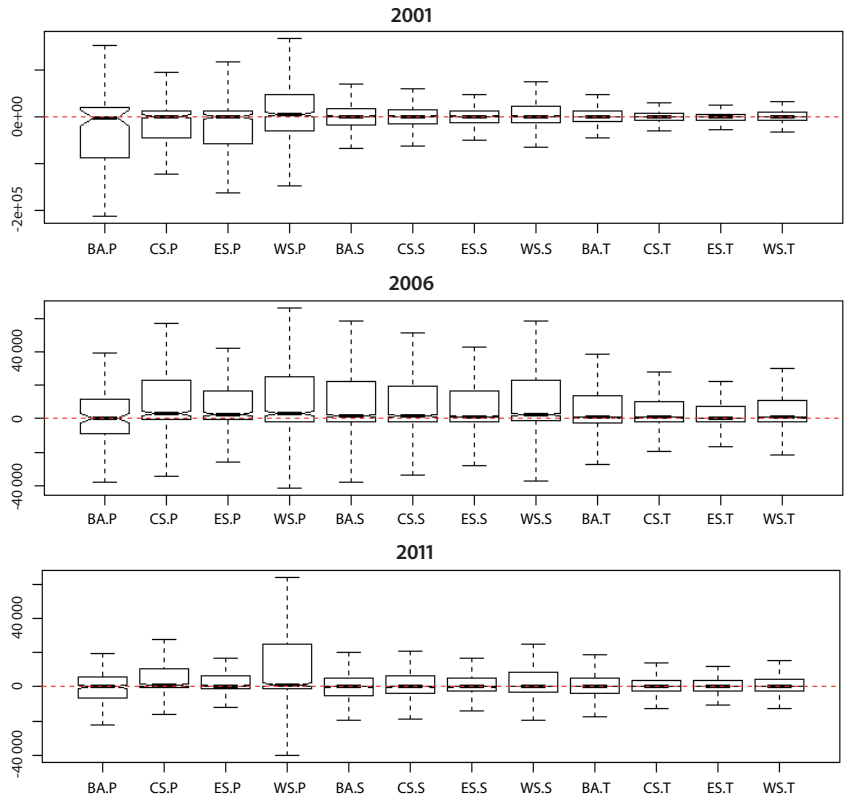


Legend: BA/CS/ES/WS: Bratislava/Central/Eastern/Western Slovak Region; P: primary, S: secondary, T: tertiary sector.
Source: Own construction

As for distribution by sectors, performance of primary sector companies improved considerably in 2006 and 2011 in comparison to 2001. Enterprises from Bratislava Region have the highest variability of *'roa'*.

Figure 2 presents the distribution of net income (profit/loss). The box plots indicate that variability of profit/loss was the highest in 2006 and lowest in 2011. Variability of net income of primary sector enterprises from Western Slovakia Region remains the highest also in 2011.

Figure 2 Distribution of profit/loss (in EUR, prices of 2005) across regions and sectors in 2001, 2006 and 2011



Legend: BA/CS/ES/WS: Bratislava/Central/Eastern/Western Slovak Region; P: primary, S: secondary, T: tertiary sector.
Source: Own construction

Table 2 Descriptive statistics

Var.	2001			2006			2011		
	median	mean	st. dev.	median	mean	st. dev.	median	mean	st. dev.
roa	0.0056	–0.0745	0.8679	0.0223	–0.0262	2.7887	0.0068	–0.0877	1.5834
siz	16.9526	16.9044	1.8006	16.1929	16.2075	1.9248	12.5738	12.6334	1.8943
liq	0.9300	1.5661	6.8211	0.9612	1.9877	13.6099	1.5297	154.0318	7094.1550
sti	0.7619	0.8464	1.3091	0.7287	0.9415	6.2211	0.0364	0.1106	1.8478
lti	0.0000	0.0902	0.2431	0.0082	0.1131	0.8403	0.0063	0.1232	1.7545
dar	0.0003	0.0031	0.1197	0.0003	0.0057	0.4546	0.0000	0.0000	0.0009
dsi	0.0002	0.0021	0.1423	0.0002	0.0015	0.0661	0.0000	0.0001	0.0047
asr	0.0014	0.0145	0.5688	0.0015	0.0166	0.6127	0.0017	0.0137	0.3672
lta	0.2152	0.3039	0.7596	0.2290	0.3104	0.2980	0.2660	0.3379	0.3813
vai	1.1530	1.3062	1.0468	1.1621	1.3383	4.0629	1.1574	1.3246	1.2049
lab	0.6918	0.8060	8.5262	0.4849	0.4856	18.7693	0.4616	0.0835	59.9087

Source: Own construction

Detailed descriptive statistics of variables used in regression analyses at national level are presented in Table 2.

According to the results relative variability of almost all variables is considerably high (coefficient of variation ranges from 0.11 for 'size' in 2001 to 717.47 for the 'ratio of labor costs to value added' in 2011).

Break-down of the results by sectors indicate that the size of companies decreased over time and is the lowest in tertiary sector companies. Liquidity of companies from all sectors improved between 2001 and 2011, while the highest median liquidity was in 2011 (mean values of liquidity in 2011 are high due to outliers, but median remains relatively stable over time). Short-term indebtedness of companies decreased over time in all sectors and very low values were reached in 2011 in comparison to 2001 and 2006. Long-term indebtedness did not change considerably during the analyzed period, and the same applies to the days accounts receivable, while asset to sales ratio changed only slightly. As one would expect, ratio of long-term assets to total assets was the highest in primary sector, and the lowest in tertiary sector. Ratio of sales revenue to cost of sales was the highest in primary sector and the lowest in tertiary sector and did not change considerably during the analyzed period. Ratio of labor costs to value added decreased considerably in all sectors. The ratio decreased from 0.84 to 0.51 in primary sector, from 0.75 to 0.55 in secondary sector and from 0.66 to 0.44 in tertiary sector. This indicates that production becomes less labor-intensive in all sectors.

As for regional distribution of the variables, companies from Eastern Slovakia region have the lowest profitability. Furthermore liquidity increased, size of companies and short-term indebtedness decreased in all regions over time. Ratio of sales revenue to cost of sales was the lowest in Eastern Slovakia Region and did not change considerably during the analyzed period. Ratio of labor costs to value added decreased sharply in all regions. The ratio decreased from around 0.64 to 0.42 in Bratislava Region and from around 0.71 to 0.47 in other regions.

2.2 The Estimated Model

The results of estimated models by years are presented in Tables 3, 4 and 5 and the corresponding Figures 3, 4 and 5. The first column of each table contains ordinary least squares (OLS) estimates, estimated coefficients in all other columns are based on quantile regression.

According to the OLS regression, 'sector' is not statistically significant at all. Variable 'region' appears as significant only in 2011. On the other hand both dummy variables were statistically significant in case of estimates based on quantile regression.

Variables *days accounts receivable, days sales of inventory, asset to sales ratio,* and *labor costs* are not statistically significant according to OLS nor quantile regression.

In all periods, there is positive statistically significant relationship between profitability and size up to the 75^{th} quantile. In the periods of 2006 and 2011, the relationship between profitability and size becomes negative at the 95^{th} quantile.

According to the results, there is not a statistically significant relationship between profitability and liquidity in 2001 and 2011, but there is a negative statistically significant relationship between profitability and liquidity in 2006 up to the 50^{th} quantile.

As for the short- and long-term indebtedness, the relationship between profitability and indebtedness is negative. However, at certain quantiles the relationship is not statistically significant.

There is not a statistically significant relationship among profitability and days account receivable, days sales of inventory, asset to sales ratio and labor costs (however, there was statistically negative relationship between profitability and labor costs at the 75^{th}, 90^{th} and 95^{th} quantiles in 2001).

For the quantiles of profitability distribution as a whole, the relationship between profitability and share of long-term assets is negative.

Further, there is positive statistically significant relationship between profitability and ratio of sales revenue to cost of sales (however, the relationship is not significant at few quantiles).

The qualitative variables 'region' and 'sector' may be interpreted relative to the omitted categories (Bratislava Region and primary sector). According to the results, up to the 50th quantile, the profitability of the companies from WS/CS/ES is higher than profitability of companies from Bratislava, but in the upper quantiles, probability of these companies is lower in comparison to the companies from Bratislava Region. Relationship between profitability and sectors yields interesting results – in 2001 and 2006 secondary and tertiary sector companies had higher profitability and primary sector firms, but the situation changed in 2011 and these companies are less profitable than primary sector firms.

For the goodness of fit diagnostics (R-squared for OLS models and $R^1(\tau)$ for quantile regression models) see the last two rows of Tables 3, 4 and 5. Values of $R^1(\tau)$ measure decrease at the higher quantiles which is due to significantly higher variability of data at higher quantiles. It means that lower quantiles are more successful in reducing variability relative to the unconditional counterpart (see e. g. Koenker and Machado, 1999 for further discussion). As p-values of the associated likelihood ratio test are <0.0001, we can conclude that the full models (with covariates) are better than the restricted models (without covariates) at all quantiles.

2.3 Discussion

In this section we will discuss the most important results described in the previous section. In Figures 3, 4 and 5, the regression coefficient at a given quantile indicates the effect on profitability of a unit change in that variable, assuming that the other variables are fixed, with 95% confidence interval bands.

In each figure the full line shows the ordinary least squares estimate of the conditional mean effect. The two dashed lines represent 95% confidence intervals for the least squares estimate. The dotted full-line depicts estimated coefficients estimated by quantile regression and the shaded grey area represents a 95% confidence band for the quantile regression estimates.

At any chosen quantile we can say, for instance, how the profitability of firms changes among sectors or regions, given a specification of the other conditioning variables.

The intercept can be interpreted as the estimated conditional quantile function of the *profitability* distribution of a primary sector company from Bratislava Region.

The relationship between profitability and size is not uniform over the distribution of profitability. The effect of size on profitability is greater at the lower quantiles than at the upper quantiles. The results suggest that there is no or very weak relationship between profitability of high profitable firms and size of the companies. The economies of scale hypothesis seems to be working for low profitable firms, as the estimated coefficients are positive, and hence the size of a company may be in positive association with its profitability.

The relationship between profitability and *short- and long-term indebtedness* is negative and the effect of indebtedness on profitability is bigger at the lower quantiles than at the upper quantiles. Again, the more profitable the firm is, the more robust to the effect of indebtedness the firm is. The results suggest that the more extensive use of debt has a negative effect on profitability of the Slovak firms. The results further show that the Slovak firms do not use debt effectively.

There is a negative relationship between profitability and *share of long-term assets*. The magnitude of long-term assets effect on profitability decreases until the 50th quantile, and then increases again. These findings suggest that high and low profitable firms are negatively affected by a high proportion of long-term assets. Such firms have excessively high proportion of the long-term assets and probably do not make an effective use of them.

The *ratio of sales revenue to cost of sales,* which might be perceived as a kind of value added index is in positive relationship with profitability. The relationship shows gradually increasing magnitude through-

out the profitability distribution. The ratio has a great importance in determining the profitability at the upper quantiles of the probability distribution and relatively low importance in determining the profitability at the lower quantiles of the probability distribution. The results further suggest that the value added is a good predictor of profit, but not such a good predictor of loss.

Also *region* has a significant effect on explaining profitability. Location of a company in a region other than Bratislava increases profitability up to the 50th quantile, but it pushes down profitability at the higher quantiles, or in other words, location of a high profitable company in Bratislava Region contributes positively to its profitability. However, for some quantiles the effect in statistical terms is insignificant. As for changes over time, the results indicate that the magnitude of location effects increase over time.

Sector is the last variable with statistically significant effects on profitability. In 2001 and 2006 secondary and tertiary sector companies showed higher profitability than primary sector companies. But the situation changed in 2011. At the lower quantiles the secondary and tertiary sector companies had lower profitability than primary sector companies, and at the higher quantiles the magnitude of the effects approaches zero, and hence sector does not play a significant role in explaining profitability in case of high profitable enterprises. These findings suggest structural changes in profitability of companies across sectors, which would require further analyses.

It is obvious that in the most of the cases the quantile regression estimates lie outside the confidence intervals for the OLS regression. This suggests that the effects of these covariates may not be constant across the conditional distribution of the profitability.

CONCLUSION

There are several possibilities how companies' profitability determinants may be identified. As variability of profitability is very high, analysis based on quantile regression is used in this paper.

The results show that the covariates are not constant across the conditional distribution of the profitability, and hence quantile regression is an appropriate method. The exploratory analysis performed in this study is based on the administrative data from the financial statements of the Slovak companies for the periods of 2001, 2006 and 2011. According to the findings size, short- and long-term indebtedness, ratio of long-term assets to total assets, ratio of sales revenue to cost of sales, region and sector are the possible determinants of profitability of the companies in Slovakia. The results further suggest that the changes over time have influenced the magnitude of the effects produced by the given variables.

The literature suggests that variables such as days accounts receivable, days sales of inventory, asset to sales ratio, and labor costs are significant determinants of profitability, but according to our results these variables are not statistically significant according to OLS nor quantile regression.

The study could be improved significantly if the number of employees of each company could be considered. But the number of employees is not collected for the tax purposes, and hence the data could not be provided. This can be perceived as one of the limitations of the study.

As region is a significant variable in determining profitability, we will focus more on spatial aspects of profitability of the Slovak enterprises in the future. Further analyses will also concentrate on differences in profitability determinants among specific NACE branches (a more detailed view of them), as it may be assumed that differences among particular NACE branches within the same sector might be significant. Such a detailed analysis is behind the scope of this paper.

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ANNEX

Table 3 Estimated regression coefficients (2001)

	OLS	Quantile regression						
		$\tau = 0.05$	$\tau = 0.10$	$\tau = 0.25$	$\tau = 0.50$	$\tau = 0.75$	$\tau = 0.90$	$\tau = 0.95$
Intercept	0.3510*** (0.0631)	–0.8999*** (0.1294)	–0.6534*** (0.0993)	–0.2738*** (0.0436)	–0.0898*** (0.0238)	–0.0069 (0.0229)	0.0940*** (0.0337)	0.1396*** (0.0472)
siz	0.0028 (0.0031)	0.0648*** (0.0066)	0.0499*** (0.0039)	0.0271*** (0.0015)	0.0123*** (0.0007)	0.0064*** (0.0008)	0.0018 (0.0012)	0.0011 (0.0020)
liq	0.0001 (0.0002)	–0.0003 (0.0082)	–0.0004 (0.0062)	–0.0006 (0.0034)	–0.0004 (0.0006)	–0.0003** (0.0001)	–0.0002 (0.0007)	–0.0002 (0.0012)
sti	–0.4385*** (0.0027)	–0.6290*** (0.0622)	–0.5015*** (0.0573)	–0.3341*** (0.0262)	–0.1922*** (0.0268)	–0.1184*** (0.0132)	–0.0747*** (0.0158)	–0.0418*** (0.0143)
lti	–0.4606*** (0.0141)	–0.3367*** (0.0786)	–0.4715*** (0.0753)	–0.2439*** (0.0719)	–0.1361*** (0.0295)	–0.0937*** (0.0129)	–0.0892*** (0.0126)	–0.1042*** (0.0131)
dar	x	x	x	x	x	x	x	x
dsi	0.0063 (0.0366)	0.0151 (0.2351)	–0.0136 (0.1631)	–0.0246 (0.2045)	–0.0034 (0.1208)	0.0024 (0.0685)	–0.0145 (0.2467)	0.0054 (0.1417)
asr	0.0049 (0.0047)	0.0093 (0.0276)	0.0046 (0.0194)	0.0003 (0.0166)	0.0011 (0.0122)	0.0011 (0.0087)	0.0054 (0.0060)	0.0054 (0.0052)
lta	–0.3849*** (0.0087)	–0.5536*** (0.1393)	–0.3897*** (0.0869)	–0.2479*** (0.0353)	–0.1209*** (0.0186)	–0.0797*** (0.0086)	–0.1239*** (0.0096)	–0.1458*** (0.0145)
vai	0.0121** (0.0054)	0.0123** (0.0049)	0.0091** (0.0038)	0.0060 (0.0051)	0.0158*** (0.0042)	0.0306*** (0.0070)	0.0630*** (0.0112)	0.0772*** (0.0171)
lab	0.0004 (0.0007)	0.0005 (0.0005)	0.0002 (0.0004)	–0.0002 (0.0004)	–0.0003 (0.0004)	–0.0004** (0.0002)	–0.0004* (0.0002)	–0.0005*** (0.0002)
regCS	0.0187 (0.0174)	0.0258 (0.0184)	0.0275* (0.0143)	0.0176*** (0.0056)	0.0058** (0.0028)	–0.0016 (0.0033)	–0.0181** (0.0069)	–0.0253** (0.0106)
regES	0.0040 (0.0173)	0.0384 (0.0246)	0.0268* (0.0138)	0.0171*** (0.0061)	0.0047* (0.0028)	–0.0052 (0.0036)	–0.0176** (0.0069)	–0.0199* (0.0112)
regWS	0.0324** (0.0160)	0.0463*** (0.0152)	0.0441*** (0.0106)	0.0190*** (0.0054)	0.0088*** (0.0026)	0.0024 (0.0034)	–0.0107 (0.0066)	–0.0210** (0.0103)
secS	0.0453 (0.0318)	–0.0056 (0.0361)	0.0258 (0.0194)	0.0347*** (0.0129)	0.0437*** (0.0104)	0.0305*** (0.0065)	0.0146 (0.0098)	0.0116 (0.0173)
secT	0.0262 (0.0298)	0.0165 (0.0402)	0.0483** (0.0260)	0.0500*** (0.0160)	0.0485*** (0.0111)	0.0319*** (0.0059)	0.0229** (0.0098)	0.0253 (0.0169)
$R^2 / R^1(\tau)$ *p-value*	0.7410 <0.0001	0.5557 <0.0001	0.4567 <0.0001	0.2881 <0.0001	0.1413 <0.0001	0.1015 <0.0001	0.0898 <0.0001	0.0893 <0.0001

Source: Own construction (standard errors estimates in parentheses; significance codes: 0 *** 0.01 ** 0.05 * 0.1)

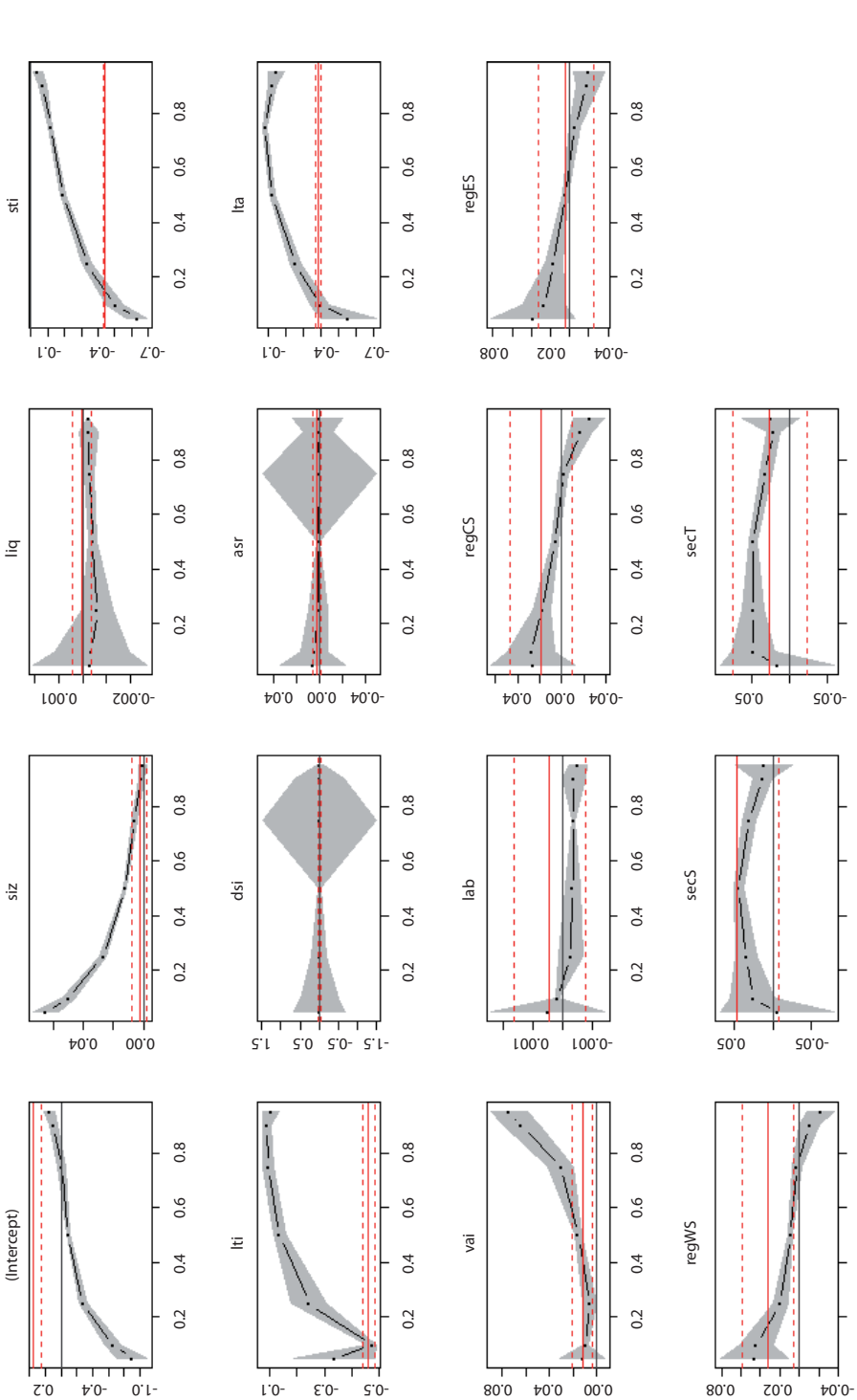

Figure 3 Ordinary least squares and quantile regression estimates for profitability model (2001)

Source: Own construction (full line: OLS mean effect estimates; dashed lines: 95% confidence intervals for OLS estimates; dotted full-line: quantile regression estimates, shaded grey area: 95% confidence band for quantile regression estimates)

Table 4 Estimated regression coefficients (2006)

	OLS	Quantile regression						
		$\tau = 0.05$	$\tau = 0.10$	$\tau = 0.25$	$\tau = 0.50$	$\tau = 0.75$	$\tau = 0.90$	$\tau = 0.95$
Intercept	–1.0592*** (0.1780)	–0.8676*** (0.0633)	–0.5899*** (0.0396)	–0.3056*** (0.0284)	–0.1238*** (0.0339)	–0.0943** (0.0416)	0.0469 (0.0434)	0.2898*** (0.0534)
siz	0.0747*** (0.0083)	0.0562*** (0.0028)	0.0420*** (0.0016)	0.0257*** (0.0008)	0.0142*** (0.0005)	0.0083*** (0.0009)	0.0016 (0.0014)	–0.0087*** (0.0021)
liq	–0.0003 (0.0012)	–0.0016* (0.0008)	–0.0023** (0.0009)	–0.0018*** (0.0006)	–0.0008* (0.0005)	0.0001 (0.0003)	0.0005 (0.0004)	0.0004* (0.0002)
sti	–0.2052*** (0.0031)	–0.5786*** (0.0447)	–0.4357*** (0.0279)	–0.2529*** (0.0218)	–0.1623*** (0.0339)	–0.0699** (0.0284)	–0.0177 (0.0165)	–0.0117 (0.0106)
lti	0.7978*** (0.0227)	–0.2928*** (0.0508)	–0.2180*** (0.0394)	–0.1233*** (0.0209)	–0.0778** (0.0319)	–0.0079 (0.0387)	0.0331 (0.0441)	0.0616 (0.0421)
dar	–0.0227 (0.0630)	–0.0006 (0.0725)	–0.0050 (0.0477)	–0.0048 (0.0280)	0.0008 (0.0340)	–0.0267 (0.0432)	–0.0580 (0.0610)	–0.0557 (0.1457)
dsi	0.0502 (0.2479)	0.0849 (0.2050)	0.0518 (0.0739)	0.0218 (0.0909)	0.0122 (0.0593)	–0.0213 (0.0752)	–0.0651 (0.1147)	–0.0778 (0.1868)
asr	0.0290 (0.0476)	0.0161 (0.0327)	0.0155 (0.0298)	0.0102 (0.0205)	0.0028 (0.0187)	0.0268 (0.0292)	0.0544 (0.0499)	0.0491 (0.1219)
lta	–0.3476*** (0.0537)	–0.2571*** (0.0290)	–0.2156*** (0.0192)	–0.1560*** (0.0096)	–0.0982*** (0.0098)	–0.1386*** (0.0102)	–0.2329*** (0.0118)	–0.2944*** (0.0195)
vai	0.0055 (0.0039)	0.0017 (0.0099)	0.0016 (0.0101)	0.0109 (0.0133)	0.0384** (0.0169)	0.1010*** (0.0199)	0.1478*** (0.0191)	0.1559*** (0.0257)
lab	0.0002 (0.0008)	0.0000 (0.0003)	0.0000 (0.0001)	–0.0001 (0.0001)	–0.0001 (0.0001)	–0.0001 (0.0002)	–0.0001 (0.0002)	–0.0001 (0.0002)
regCS	0.0004 (0.0450)	0.0584*** (0.0132)	0.0354*** (0.0084)	0.0203*** (0.0037)	0.0073*** (0.0023)	0.0033 (0.0031)	–0.0136** (0.0060)	–0.0189* (0.0102)
regES	–0.0296 (0.0460)	0.0475*** (0.0143)	0.0295*** (0.0080)	0.0145*** (0.0038)	–0.0009 (0.0025)	–0.0112*** (0.0033)	–0.0275*** (0.0062)	–0.0365*** (0.0093)
regWS	0.0020 (0.0414)	0.0445*** (0.0129)	0.0305*** (0.0077)	0.0162*** (0.0035)	0.0014 (0.0020)	–0.0060* (0.0034)	–0.0118** (0.0057)	–0.0205** (0.0094)
secS	0.0046 (0.1088)	0.0453** (0.0179)	0.0592*** (0.0140)	0.0407*** (0.0082)	0.0240*** (0.0082)	0.0255*** (0.0054)	0.0328*** (0.0101)	0.0573*** (0.0161)
secT	0.0366 (0.1037)	0.0717*** (0.0163)	0.0733*** (0.0127)	0.0508*** (0.0077)	0.0269*** (0.0087)	0.0274*** (0.0050)	0.0389*** (0.0089)	0.0619*** (0.0145)
$R^2 / R^1(\tau)$ *p-value*	0.1482 <0.0001	0.4493 <0.0001	0.3679 <0.0001	0.2208 <0.0001	0.1035 <0.0001	0.0721 <0.0001	0.0626 <0.0001	0.0529 <0.0001

Source: Own construction (standard errors estimates in parentheses; significance codes: 0 *** 0.01 ** 0.05 * 0.1)

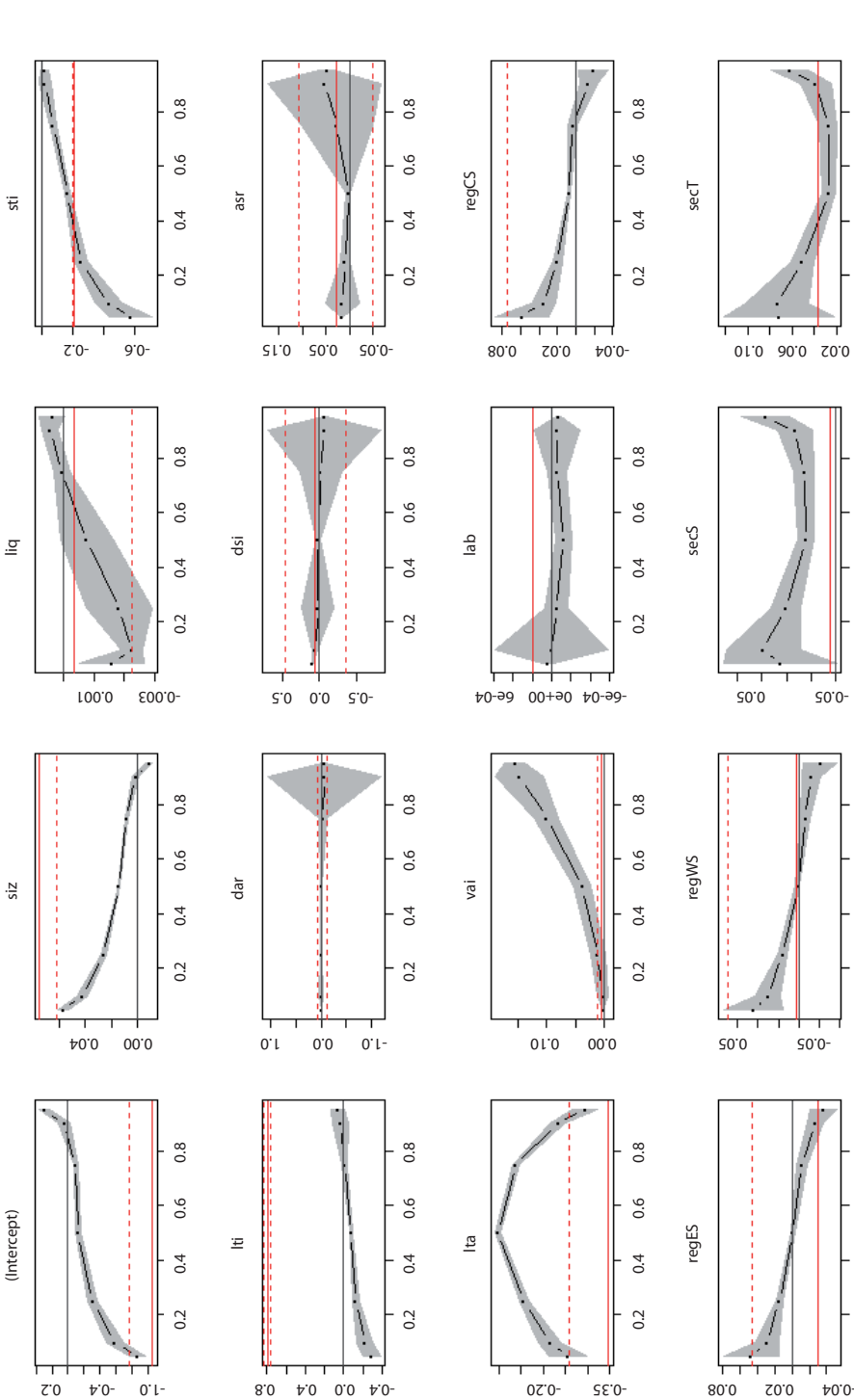

Figure 4 Ordinary least squares and quantile regression estimates for profitability model (2006)

Source: Own construction (full line: OLS mean effect estimates; dashed lines: 95% confidence intervals for OLS estimates; dotted full-line: quantile regression estimates, shaded grey area: 95% confidence band for quantile regression estimates)

Table 5 Estimated regression coefficients (2011)

	OLS	Quantile regression						
		$\tau = 0.05$	$\tau = 0.10$	$\tau = 0.25$	$\tau = 0.50$	$\tau = 0.75$	$\tau = 0.90$	$\tau = 0.95$
Intercept	–0.5403*** (0.0698)	–1.9247*** (0.0708)	–1.2746*** (0.0359)	–0.5582*** (0.0224)	–0.2169*** (0.0122)	–0.1159*** (0.0164)	0.0951** (0.0481)	0.2814** (0.1126)
siz	0.0425*** (0.0038)	0.1199*** (0.0035)	0.0794*** (0.0022)	0.0345*** (0.0013)	0.0133*** (0.0007)	0.0075*** (0.0007)	–0.0022 (0.0016)	–0.0084** (0.0040)
liq	0.0000 (0.0000)	0.0000 (0.0000)	0.0000 (0.0000)	0.0000 (0.0000)	0.0000 (0.0000)	0.0000 (0.0000)	0.0000 (0.0000)	0.0000 (0.0000)
sti	–0.0031 (0.0038)	–0.7027*** (0.1960)	–0.3486** (0.1393)	–0.0794 (0.0515)	–0.0186 (0.0317)	0.0031 (0.0393)	0.0030 (0.0587)	0.0027 (0.0997)
lti	–0.5258*** (0.0041)	–0.4183*** (0.1134)	–0.4377*** (0.0507)	–0.3073*** (0.0473)	–0.1451*** (0.0427)	–0.1048*** (0.0394)	–0.1407** (0.0698)	–0.1740* (0.1026)
dar	4.8320 (7.9870)	5.6407 (15.6500)	3.3387 (6.5154)	1.1647 (3.3495)	0.2201 (0.9655)	–0.3750 (1.7039)	2.1300 (3.0560)	0.0258 (4.0675)
dsi	0.9409 (1.4780)	1.5512 (1.1246)	0.9777 (0.6920)	0.4133 (0.3182)	0.1454 (0.2512)	0.0610 (0.1729)	–0.1412 (0.2211)	–0.3306 (0.2079)
asr	0.0278 (0.0192)	0.0229 (0.0183)	0.0243 (0.0175)	0.0186* (0.0115)	0.0093 (0.0063)	0.0121 (0.0102)	0.0128 (0.0123)	0.0044 (0.0114)
lta	–0.2473*** (0.0191)	–0.2877*** (0.0641)	–0.1723*** (0.0365)	–0.0958*** (0.0110)	–0.0615*** (0.0044)	–0.0975*** (0.0051)	–0.1755*** (0.0239)	–0.2248*** (0.0487)
vai	0.0611*** (0.0058)	0.0545*** (0.0137)	0.0649*** (0.0125)	0.0738*** (0.0070)	0.0699*** (0.0056)	0.1136*** (0.0090)	0.1570*** (0.0216)	0.1560*** (0.0393)
lab	0.0001 (0.0001)	0.0002 (0.0004)	0.0001 (0.0002)	0.0001* (0.0000)	0.0001 (0.0001)	0.0001 (0.0001)	0.0001 (0.0001)	0.0001 (0.0001)
regCS	0.0612*** (0.0203)	0.1807*** (0.0248)	0.1140*** (0.0122)	0.0371*** (0.0040)	0.0106*** (0.0019)	0.0018 (0.0030)	–0.0028 (0.0057)	–0.0080 (0.0098)
regES	0.0489** (0.0207)	0.1449*** (0.0266)	0.0933*** (0.0121)	0.0324*** (0.0045)	0.0061*** (0.0018)	–0.0060** (0.0031)	–0.0221*** (0.0066)	–0.0306*** (0.0112)
regWS	0.0444** (0.0185)	0.1631*** (0.0256)	0.1038*** (0.0112)	0.0328*** (0.0037)	0.0091*** (0.0017)	0.0012 (0.0025)	–0.0090 (0.0057)	–0.0159 (0.0110)
secS	–0.0383 (0.0482)	–0.1814*** (0.0282)	–0.0983*** (0.0150)	–0.0363*** (0.0055)	–0.0136*** (0.0036)	–0.0153*** (0.0054)	–0.0254** (0.0108)	–0.0177 (0.0186)
secT	–0.0585 (0.0457)	–0.1987*** (0.0253)	–0.1043*** (0.0135)	–0.0303*** (0.0054)	–0.0097*** (0.0032)	–0.0106** (0.0054)	–0.0102 (0.0113)	–0.0007 (0.0169)
$R^2 / R^1(\tau)$ *p-value*	0.3666 <0.0001	0.1489 <0.0001	0.1327 <0.0001	0.0916 <0.0001	0.0476 <0.0001	0.0705 <0.0001	0.1050 <0.0001	0.1190 <0.0001

Source: Own construction (standard errors estimates in parentheses; significance codes: 0 *** 0.01 ** 0.05 * 0.1)

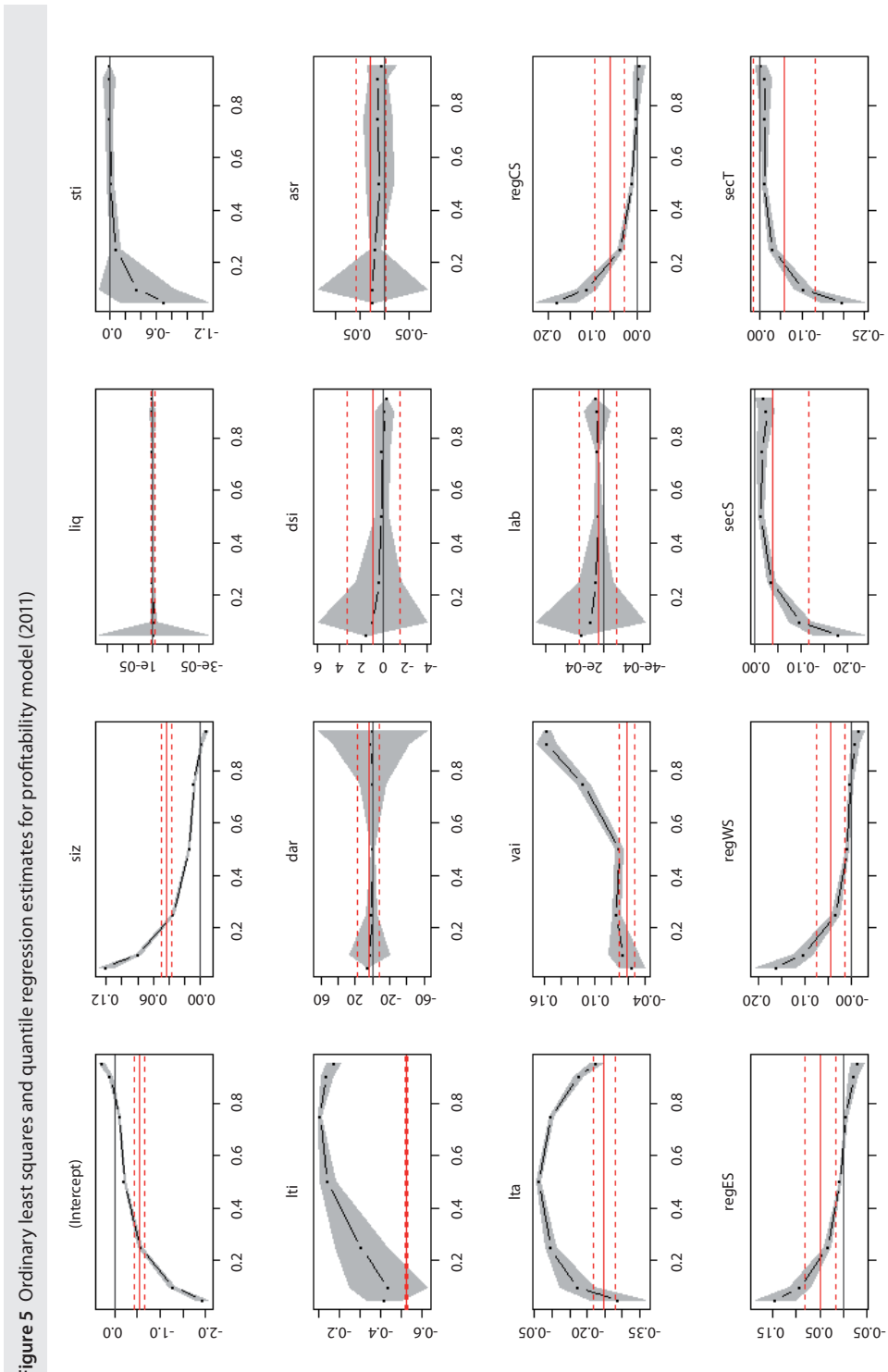

Figure 5 Ordinary least squares and quantile regression estimates for profitability model (2011)

Source: Own construction (full line: OLS mean effect estimates; dashed lines: 95% confidence intervals for OLS estimates; dotted full-line: quantile regression estimates, shaded grey area: 95% confidence band for quantile regression estimates)

An Application of the Harmonic Oscillator Model to Verify Dunning's Theory of the Economic Growth

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Abstract

Analogies with mechanisms ruling the natural world have often been sought in the course of economic phenomena. This paper is also an attempt to combine the physical phenomenon of a harmonious oscillator with the theory of economic growth by J. H. Dunning (1981). In his theory, Dunning distinguished stages of economic growth of countries that imply the dependency between the investment position of countries and their GDP per capita, while the graph presenting this dependency reminds a trajectory of oscillating motion of a damped harmonic oscillator. This analogy has given inspiration to reinterpret the theory of economy on the grounds of the mechanism of a physical model. In this paper, the harmonious oscillator motion equation was adapted to the description of dependencies shown in the theory of economic growth by J. H. Dunning. The mathematical solution of this equation is properly parameterised and parameters are estimated with the use of the Gauss-Newton algorithm. The main objective of this paper is to allocate a specific stage in the economic growth to each country on the basis of the values of parameter estimations of the proposed cyclical models of changes in the net investment indicator.

Keywords

Dunning's theory, convergence, Gauss-Newton algorithm

JEL code

C51

INTRODUCTION

Dependencies between the country's economic growth and the level of inward and outward foreign direct investments are the subject of numerous research works. There is a range of economic theories attempting to describe such dependencies. One of these theories which is really worth attention is the theory of economic growth formulated by J. H. Dunning (1981). In his theory, Dunning distinguished stages of economic growth that imply the dependency between the investment position of countries (NOI *per capita*[2]) and their GDP *per capita*, while the graph showing this dependency reminds a tra-

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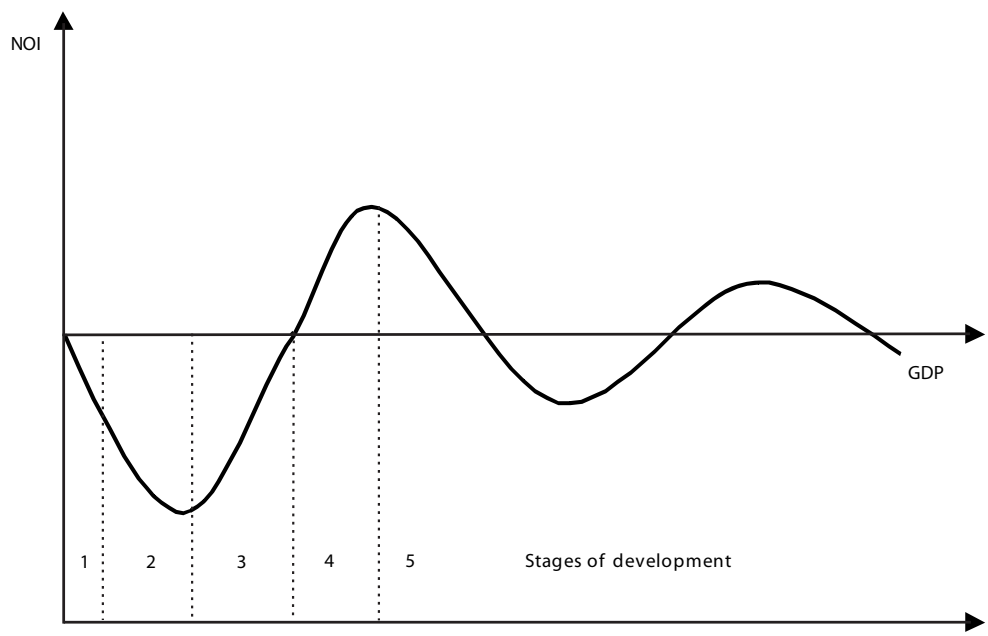
[2] Net outward investment (NOI) is the difference between foreign investments located outside the borders of a given country by companies based in this country and foreign investments executed by foreign companies within the territory of this country (Dunning, 1981).

jectory of oscillating motion of a damped harmonic oscillator. This analogy has inspired the author of this article to reinterpret the theory of economy on the grounds of the mechanism of the operation of a physical model. In this article, the harmonic oscillator motion equation was adapted to describe the dependencies presented in J. H. Dunning's economic growth theory. Through the proper parameterisation, the proposed econometric model describes the path of the country's investment development in the dynamic perspective, which allows for allocating the country to the relevant stage of economic growth distinguished in J. H. Dunning's theory. An advantage of this model lies also in its capacity to detect convergence or divergence phenomena in the country's investment development. The elementary objective of this article is to allocate the relevant stages in the economic growth to the examined countries on the basis of the estimated parameters of the proposed model of cyclical changes in the net investment index. The model was also estimated separately for each economy sector, thanks to which it is possible to compare the dynamics of economic growth from the sector perspective. The results of the ordering of economy sectors to individual stages of development was then subjected to the cluster analysis, which allowed for indicating a group of countries most similar in terms of the level of economic growth in the sector perspective. The research covered 10 selected countries from Central and Eastern Europe being EU members. Eurostat data for the period 1995–2012 was used in calculations.

1 REVIEW OF LITERATURE

In his theory, J. H. Dunning (1981) distinguished five stages of the country's economic growth, which are strictly connected with the level of GDP *per capita* as well as values and directions of changes in NOI *per capita*. These stages occur consecutively, creating a sort of an investment development path. The course of such a pattern path is illustrated in Figure 1.

Figure 1 Pattern of the path of the country's economic growth according to J. H. Dunning's theory



Source: Dunning, Narula (2002).

The stages of economic growth distinguished by J. H. Dunning may be characterised as follows (Stawicka, 2008):

- Countries with the weakest economy with GDP *per capita* below USD 400[3] in which the value of NOI *per capita* is close to zero and negative undergo the first stage of development. These countries are characterised by the deficit of capital, so they do not export foreign direct investments themselves but at the same time do not attract foreign capital, either;
- The second stage of growth involves countries with GDP *per capita* from the range of USD 400–1 500 and is characterised by the negative value of NOI *per capita*. Countries being at this stage of growth are to a certain extent more attractive to foreign investors but still have too low supply of capital to export foreign direct investments;
- The third stage of growth involves countries with GDP *per capita* from the range of USD 2 000–4 750 having a negative but increasing value of NOI *per capita*. These countries conduct their own foreign direct investments more and more often but the scale of these investments is lower than inward foreign direct investments in these countries;
- The fourth and fifth stage involves highly developed countries with GDP *per capita* above USD 2 600 in which NOI *per capita* is usually positive, which shows that these countries are active exporters of foreign direct investments.

The course of the curve illustrating the dependence of NOI *per capita* on the value of GDP *per capita* presented in Figure 1 reminds the oscillating motion of a damped harmonic oscillator. The application of the harmonic oscillator model in describing economic phenomena (especially the modelling of economic development) is known in the theory of economics (Chiang, 1994) but few researchers were able to use it in the empirical verification of J. H. Dunning's theory of economic growth (Kayam, Hisarciklilar, 2009). In the research conducted so far that verifies this theory there is predominance of polynomial regression models (Barry, Görg, McDowell, 2002, Buckley, Castro, 1998). However, solutions of this kind are not free of defects, including limitations in the possibility of interpreting the parameters of polynomial models and the resulting difficulties with ordering countries to a specific stage of economic growth. The proposed model is based on the mechanism of a harmonious oscillator, so it seems to be a solution competitive to traditional approaches to the verification of J. H. Dunning's theory of economic growth.

2 RESEARCH METHODS

In general, the oscillator motion equation takes the following form (Zill, 1986):

$$\frac{d^2x}{dt^2} + 2\beta\frac{dx}{dt} + \varpi_0^2 x = 0, \tag{1}$$

where:

x – displacement of the oscillator from the equilibrium position,

t – time,

β – elasticity index,

ω_0 – frequency of free vibrations.

Equation (1) is commonly used to describe the motion of a mechanical oscillator or an electromagnetic oscillator dampened by external factors (forces of resistance, friction, etc.).

[3] Boundary values of GDP per capita specified by J. H. Dunning are no longer valid (they were determined on the basis of data for the period 1967–1978). However, the very mechanism of identifying the stages of economic growth is constantly used in research works devoted to economic growth and in reports of institutions monitoring economic growth (e.g. UNCTAD).

Equation (1) is a homogeneous second-order differential equation the solution of which in case of weak dampening (i.e. when β< ω0) takes the form:

$$x = x_0 e^{-\beta t} \cos(\omega t + \varphi), \tag{2}$$

where:

$\omega = \sqrt{\omega_0^2 - \beta^2}$,

φ – phase shift,

x_0 – initial displacement of the oscillator.

If one assumes that values of NOI *per capita* change approximately according to equation (1), then with the use of function (2) one can formulate the following model describing cyclical changes of this index:

$$NOI_t = \alpha e^{-\beta PKB_t} \cos(\gamma PKB_t) + \varepsilon_t. \tag{3}$$

In model (3) there are three parameters requiring estimation: α, β, γ, that characterise the course of dependence between NOI and GDP in the following manner:

1. Parameter α determines the initial value of amplitude (with $\beta = 0$) and the starting direction of changes in NOI (increase towards the positive orientation of the vertical axis of the Cartesian coordinate system, when $\alpha>0$ or decrease towards the negative orientation of this axis when $\alpha<0$). The value of parameter α estimator may also suggest the capacity of the economy to absorb foreign direct investments or export own foreign direct investments. High and negative estimation value of parameter α estimator may suggest strong investment competition of the economy of a given country which is effective in attracting foreign capital. High and positive estimation value of this parameter, in turn, may indicate high economic potential (with considerable supply of capital) of the country actively conducting foreign direct investments.

2. Parameter determines the intensity of vibration dampening. Depending on the sign of parameter β, displacements from the equilibrium position can have threefold character:

- $\beta >0$ indicates decreasing displacements,
- $\beta < 0$ indicates increasing displacements,
- $\beta = 0$ indicates the constant amplitude of displacements.

The positive value of parameter β can indicate symptoms of convergence[4] which results in the economy of a given country becoming similar to the economies of highly developed countries in the range of the pattern of the investment development path. The negative value of parameter β may be interpreted as the occurrence of a phenomenon opposite to convergence, i.e. divergence, which results in greater distance in the investment development in relation to the economies of developed countries.

3. Parameter γ indicates the length of one cycle in oscillatory motion (distance between two successive upper or lower turning points), whereas the full cycle period is $2\pi\gamma^{-1}$. A longer cycle period is characteristic of better developed economies while the shorter one occurs in general in economies at a weaker level of development.

The analysis of a specific configuration of the values of estimations of the discussed parameters makes it possible to locate a considered country in one of the stages of economic growth defined by J. H. Dunning. The expected stages in the development of countries are presented in Figure 1, depending on the estimators of parameters α and β.

[4] Convergence involves the penetration of economy patterns of countries with a similar level of wealth and differentiation of patterns in countries with different wealth levels (Woźniak, 2005).

When analysing the content of table 1, it should be stressed that if parameter α does not differ considerably from zero, then the country may be in the first stage of development or at the beginning of the fourth stage (the amplitude of oscillation is inconsiderable then). In this situation, the familiarity with the sign of parameter α estimator can be helpful in classifying a country into one of the stages: a positive sign indicates the fourth stage while the negative one suggests the first stage.

It must be also stated that the classification of countries into the second or third stage may not be strict (in case $\alpha < 0$ and $\beta < 0$). In that case, when allocating to one of the stages, one can also use the estimator of parameter γ which – if known – enables the calculation of the length of the cycle ($2\pi\gamma^{-1}$). The results of empirical research confirm that a higher level of GDP is associated with a longer stage of the cycle (so a lower value of the estimator of parameter γ) (Kayam, Hisarciklilar, 2009). Low and statistically significant values of the estimators of parameter γ may suggest a higher level of the country's economic growth.

Table 1 Stages of economic growth depending on the signs of parameters α and β in model (3)

Estimator signs		Stage of economic growth
α	β	
0*)	any	1 or 4
–	–	2 or 3
–	+	3
+	–	4
+	+	5

*) Zero value is to be understood as a statistically insignificant result.
Source: Own elaboration

3 RESULTS AND DISCUSSION

3.1 Results of the estimation of the harmonic oscillator model for the countries of Central and Eastern Europe

The parameters of model (3) were estimated for ten countries of Central and Eastern Europe being member states of the European Union on the basis of the data for the period 1995–2012, with the use of the non-linear method of least squares – the Gauss–Newton algorithm. This method is an iterative procedure of conducting a range of successive implementations of the least squares method whereas each model iteration is substituted with a linear approximation obtained in the development of the Taylor's theorem with the accuracy to the first derivatives around the approximation of parameters (Goryl, 2004). The application of the Gauss–Newton algorithm requires the specification of starting values of parameters (in the literature on the subject, the application of the method of m points or m sums is proposed), which are then "corrected" in the course of successive iterations until the convergence of the algorithm is obtained (the degree of convergence may be controlled with the use of stopping criteria). In this research, the non-linear estimation of model (3) was conducted with the use of the Gauss–Newton algorithm programmed in the STATISTICA computer package (version 9.1).

The results of the estimation of parameters of model (3) are presented in Table 2 (in brackets under estimations of parameters test probabilities p are to be found). The chart also contains values of the model's coefficients of determination and numbers of stages in the economic growth ordered for individual countries on the basis of the values of parameter estimations.

When analysing the results from Table 2, it should be stated that some results are not statistically significant, therefore despite the generally good match of the estimated model (3) to empirical data, conclusions about the unambiguous allocation of individual countries to specific stages in the development must be formulated carefully in some cases.

Table 2 Results of estimation of the parameters of model (3) for the countries of Eastern and Central Europe

Country	Parameter			Coefficient of determination R^2 (%)	Stage of development
	α	β	γ		
Bulgaria	–10.898	–0.002	0.000	55.47	2–3
	(0.030)	(0.982)	(0.995)		
Czech Republic	–3.372	0.002	0.154	89.21	3
	(0.035)	(0.021)	(0.310)		
Estonia	–8.191	–0.004	0.000	60.47	2–3
	(0.005)	(0.083)	(0.954)		
Hungary	–2.067	–0.005	0.000	80.11	2–3
	(0.014)	(0.001)	(0.894)		
Latvia	–3.946	–0.000	0.240	48.72	1
	(0.977)	(0.998)	(0.000)		
Lithuania	–3.487	–0.004	0.000	83.47	2–3
	(0.008)	(0.025)	(0.947)		
Poland	–15.201	0.011	0.110	75.19	3
	(0.043)	(0.186)	(0.000)		
Romania*)	5.621	0.001	0.153	---	---
	(0.803)	(0.957)	(0.109)		
Slovakia	1 958.736	–0.005	0.000	49.55	4
	(0.667)	(0.000)	(0.934)		
Slovenia	–156.906	0.000	0.000	90.97	3
	(0.028)	(0.012)	(0.048)		

*) Stable estimations of parameters with the use of the Gauss-Newton algorithm were not obtained for Romania.
Source: Own elaboration

On the basis of the results showed in Table 2, it seems that the highest fourth stage of the economic growth was achieved by Slovakia. But this classification must be treated with caution as parameters α and γ were not statistically significant in model (3) estimated for Slovakia and the very model is adjusted rather moderately well to statistical data.

Czech Republic, Poland and Slovenia may be classified in the third stage of economic growth. But while in case of Czech Republic and Slovenia, parameter β turned out to be statistically significant (at the significance level of 0.05), then in case of Poland this parameter is not significant, so the classification of Poland to the third stage of growth must be done with certain caution.

The results of the estimation of parameters in model (3) most frequently indicated the second or third stage of growth in the examined countries. This situation occurred in case of Bulgaria, Estonia, Lithuania and Hungary. It should also be pointed out that model (3) estimated only for Lithuania and Hungary had both parameters α and β statistically significant and in relation to these countries the conclusion concerning the classification to the second or third stage seems particularly "strong". However, parameter γ estimated for these countries was not statistically significant, which makes it impossible to determine the length of the cycle stage in a reliable way and to allocate each of these countries to one of two stages (second or third) in an unambiguous way.

The lowest level of growth was allocated to Latvia (first stage of growth) but here it should be emphasised that key parameters decisive for categorising the country to a specific stage of growth are not statistically significant. Stable estimations of the parameters of model (3) were not obtained only in case of Romania, so it was not possible to allocate this country to the relevant stage of economic growth.

Parameter β achieved a positive and statistically significant value in model (3) estimated for the Czech Republic and Slovenia. This suggests that clear symptoms of decreasing proportions in the investment development may occur in these countries in relation to the majority of "old" EU countries. In the model estimated for Poland, parameter β is positive (and may suggest convergence) but statistically insignificant. In other countries, the negative value of the parameter β estimators suggests symptoms of divergence, i.e. the possibility of increasing distance in the investment development compared to economically developed countries. However, only in model (3) built for Lithuania, Slovakia and Hungary, parameter β turned out to be negative and statistically significant, which suggests that divergence may be distinct there.

3.2 Results of the estimation of the harmonious oscillator model for economy sectors in the countries of Central and Eastern Europe

J. H. Dunning's theory is usually verified with reference to the whole economy of the country. As economy is a complex structure in which different sections or sectors can develop at a different pace and usually bring different contributions to the growth of the country, it seems that the verification of J. H. Dunning's theory is justified, also in the sector perspective of economy. To this end, model (3) was estimated for Central and Eastern Europe countries separately for agriculture, processing industry, construction and services.[5] This allowed for tracking and comparing investment development paths of the examined countries in the elementary sectors of economy. In the calculations for individual sectors, the values of GDP *per capita* were substituted with the gross value added (GVA) generated in individual sectors of economy in the period 1995–2012. Table 3 presents the results of estimation for model (3) describing the development of agriculture in the countries of Central and Eastern Europe.

Table 3 Results of the estimation of the parameters of the investment development path in agriculture in the countries of Central and Eastern Europe

Country	Parameter			Coefficient of determination R^2 (%)	Stage of development
	α	β	γ		
Bulgaria	–15.201 (0.003)	–0.011 (0.686)	0.110 (0.000)	28.02	2–3
Czech Republic	–10.898 (0.040)	0.000 (0.982)	0.000 (0.995)	27.31	3
Hungary	–1 958.736 (0.037)	0.005 (0.000)	0.000 (0.934)	73.10	3
Estonia	–3.372 (0.365)	–0.002 (0.821)	0.154 (0.000)	30.16	1
Latvia	–3.946 (0.977)	0.000 (0.998)	0.240 (0.000)	42.63	1
Lithuania	–8.191 (0.005)	–0.004 (0.083)	0.000 (0.954)	20.54	2–3
Poland	3.487 (0.008)	–0.004 (0.025)	0.000 (0.947)	65.79	2–3
Romania	–2.067 (0.014)	–0.005 (0.001)	0.000 (0.894)	43.51	2–3
Slovakia	5.621 (0.803)	–0.001 (0.957)	0.153 (0.000)	43.36	4
Slovenia	–156.906 (0.028)	0.000 (0.012)	0.000 (0.048)	78.60	3

Source: Own elaboration

[5] Usually 3 economy sectors are distinguished: agriculture (with forestry and fishery), industry (with construction industry) and services. For the purpose of this research, this division was particularised by separating processing industry from construction.

On the basis of the results contained in Table 3, it can be deduced that Slovakia achieved the highest fourth stage in the development of agriculture. This conclusion is weakened by the lack of significance of key parameters of model (3) built for the Slovak agriculture. The third stage of the investment development of agriculture is observed in the Czech Republic, in Slovenia and in Hungary.

Parameters of model (3) estimated for Bulgaria, Lithuania, Poland and Romania suggest that the agriculture of these countries may be classified in the second or third stage of economic development. However, it is difficult to specify clearly a concrete stage in the development of these countries as parameter γ determining the length of the cycle stage in case of Lithuania, Poland and Romania is not statistically significant.

On the basis of the estimation results of model (3), it can be stated that the youngest, first stage of economic growth is represented by agriculture in Latvia and Estonia. However, the last result of classification should be treated as "approximate" as parameter α is not statistically significant both in the model estimated for Latvia and Estonia. Positive and statistically significant estimators of parameter β were obtained only for Slovenia and Hungary, which means that the agriculture of these countries may undergo convergence.

Table 4 presents the results of the estimation of model (3) describing the development of processing industry in the countries of Central and Eastern Europe.

Table 4 Results of the estimation of the parameters of the model of the investment development path in processing industry in the countries of Central and Eastern Europe

Country	Parameter			Coefficient of determination R^2 (%)	Stage of development
	α	β	γ		
Bulgaria	–50.065 (0.029)	–0.001 (0.642)	0.510 (0.000)	58.11	2–3
Czech Republic	2.579 (0.038)	–0.005 (0.413)	0.039 (0.000)	47.14	4
Hungary	–2 411.874 (0.032)	0.000 (0.000)	0.000 (0.952)	89.75	3
Estonia	–67.547 (0.016)	–0.001 (0.000)	0.000 (0.406)	76.69	2–3
Latvia	–1.294 (0.044)	–0.005 (0.061)	0.043 (0.000)	37.98	2–3
Lithuania	–20.051 (0.524)	–0.002 (0.020)	0.011 (0.000)	28.47	1
Poland	0.491 (0.079)	–0.003 (0.503)	0.018 (0.000)	52.21	4
Romania	–880.422 (0.435)	0.000 (0.907)	0.005 (0.000)	45.52	1
Slovakia	–221.924 (0.000)	0.000 (0.045)	0.000 (0.952)	88.97	3
Slovenia	–187.044 (0.028)	0.000 (0.012)	0.000 (0.048)	75.14	3

Source: Own elaboration

Table 4 shows that the highest level of investment development (fourth stage) in processing industry was achieved by the Czech Republic and Poland, whereas only in case of the Czech Republic this conclusion is strong since the index α calculated in model (3) for this country was statistically significant. Slovakia, Slovenia and Hungary may be classified in the third stage of investment development in processing industry. Processing industry of Bulgaria, Estonia and Latvia is in the second or third stage of development but Latvia seems to be the country most advanced towards the third stage (with the duration

of the cycle longer than in case of Bulgaria; for Estonia, it is impossible to calculate a reliable length of the development cycle stage as parameter γ is not statistically significant). The weakest level of processing industry development (stage one) is characteristic of Lithuania and Romania while this conclusion should be treated with caution as parameter α is not statistically significant both in the model estimated for Lithuania and Romania. In the light of the obtained results, the phenomenon of convergence in processing industry is distinct in Slovakia, Slovenia and Hungary (for these countries only, parameter β was positive and statistically significant).

Table 5 Results of the estimation of the parameters of the investment development path in construction in the countries of Central and Eastern Europe

Country	Parameter			Coefficient of determination R^2 (%)	Stage of development
	α	β	γ		
Bulgaria	–23.420 (0.005)	–0.001 (0.526)	0.000 (0.935)	66.21	2–3
Czech Republic	–19.027 (0.019)	–0.007 (0.000)	0.000 (0.931)	89.09	2–3
Hungary	304.985 (0.058)	0.146 (0.257)	–2.608 (0.000)	62.17	4
Estonia	–1.814 (0.696)	–0.003 (0.309)	0.032 (0.000)	40.74	1
Latvia	–8.907 (0.000)	–0.002 (0.002)	0.000 (0.843)	61.97	2–3
Lithuania	–7.726 (0.008)	–0.002 (0.001)	0.000 (0.746)	71.46	2–3
Poland	–13.149 (0.001)	–0.002 (0.201)	0.000 (0.900)	87.74	2–3
Romania*)	–7.624 (0.860)	–0.003 (0.752)	0.000 (0.934)	---	---
Slovakia	–19.167 (0.045)	–0.001 (0.402)	0.000 (0.970)	35.31	2–3
Slovenia	14.998 (0.810)	0.047 (0.815)	–0.420 (0.949)	33.04	4

*) Stable estimations of parameters with the use of the Gauss-Newton algorithm were not obtained for Romania.
Source: Own elaboration

Table 5 suggests that in the majority of the compared countries, i.e. Bulgaria, Czech Republic, Lithuania, Latvia, Poland and Slovakia, the construction industry is in the second or third stage of development. On the basis of the evaluation of parameter γ in these countries it was also hard to state towards which stage of development they are shifted as in none of the countries categorised in the second or third stage of development parameter γ was statistically insignificant.

Slovenia and Hungary exhibit the highest, fourth stage of development in construction but parameter α was not statistically significant for any of the countries, so the conclusion formulated here should be treated carefully. The first and least mature stage of investment development is observed in Estonia's construction industry but this is a weak conclusion as it is based on statistically insignificant parameter α. Only Romania was not classified to any stage of development as the Gauss-Newton algorithm in model (3) estimated for this country did not achieve convergence. None of the countries did observe significant convergence in construction while the phenomenon of distinct divergence took place in the Czech Republic, Lithuania and Latvia.

Table 6 presents the results of the estimation of model (3) describing the development of services in the countries of Central and Eastern Europe.

Table 6 Results of the estimation of the parameters of the investment development path model in services in the countries of Central and Eastern Europe

Country	Parameter			Coefficient of determination R^2 (%)	Stage of development
	α	β	γ		
Bulgaria	–55.325 (0.008)	–0.001 (0.000)	0.002 (0.000)	71.28	2–3
Czech Republic	1.802 (0.710)	–0.003 (0.027)	0.006 (0.000)	79.73	4
Hungary	–1 817.228 (0.031)	0.000 (0.703)	0.000 (0.866)	72.84	3
Estonia	–40.680 (0.645)	0.000 (0.829)	0.000 (0.154)	31.63	1
Latvia	–71.453 (0.481)	0.000 (0.114)	0.001 (0.000)	39.67	1
Lithuania	–37.516 (0.007)	–0.001 (0.000)	0.001 (0.000)	42.74	2–3
Poland	–263.832 (0.000)	0.000 (0.000)	0.000 (0.000)	72.58	3
Romania	–9 470.170 (0.111)	0.000 (0.275)	0.000 (0.208)	21.99	1
Slovakia	–757.479 (0.046)	0.000 (0.698)	0.000 (0.907)	57.01	3
Slovenia	–917.951 (0.043)	0.000 (0.871)	0.000 (0.024)	68.08	3

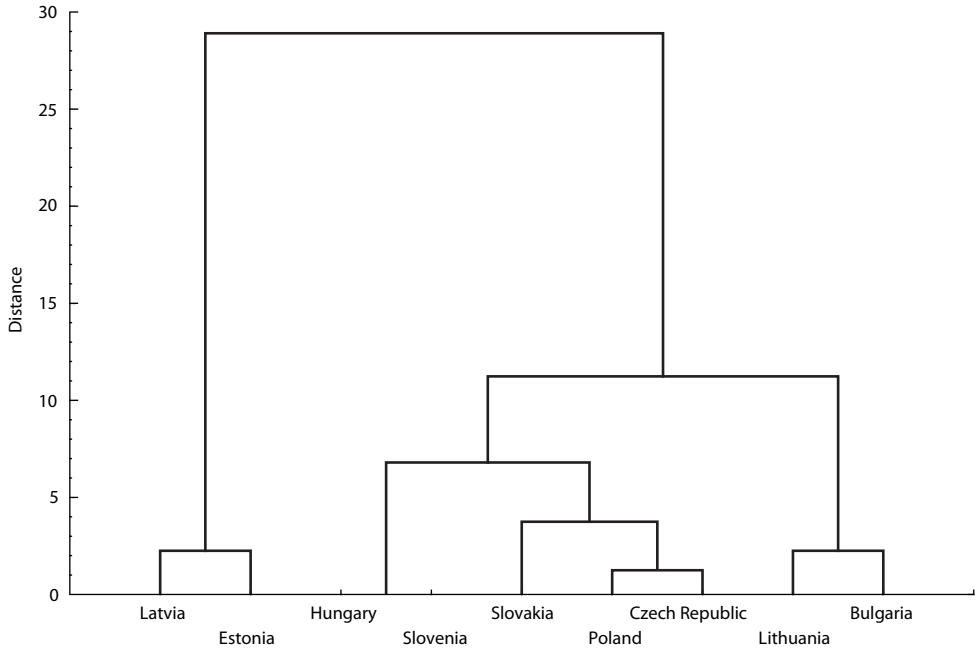
Source: Own elaboration

Table 6 suggests that among the compared countries the predominant ones are in the third stage of investment development of the service sector. The highest, fourth stage of the development of services was achieved in the Czech Republic but this classification should be treated with caution as parameter α estimated for this country was not statistically significant. In the second or third stage of the development of the service sector, there is Bulgaria and Lithuania, while the lowest value of parameter γ for Lithuania may suggest that it is shifted towards the third stage of development than in case of Bulgaria. Negative and statistically insignificant evaluations of parameter α for Estonia, Latvia and Romania indicate that these countries are in the first stage of investment development of the service sector. Among the compared countries, only Poland observed significant convergence in the service sector and the distinct divergence occurred in Bulgaria, the Czech Republic and Lithuania.

3.3 Comparison of the level of economic growth of the countries of Central and Eastern Europe

In order to determine which countries are most similar in terms of the level of economic growth, they were grouped with the use of the Ward's method with squared Euclidean distance. When choosing this method of grouping objects, their popularity and effectiveness confirmed with numerous empirical research works were taken as a criterion (Sokołowski, 1992). The results of the classification of countries in particular stages of economic growth were used while grouping (Tables 3–6). Characteristics used in the cluster analysis included levels of economic growth (1–4) attributed to individual countries in each of the following economy sectors: agriculture, processing industry, construction and services. In case of non-acute classification to a specific stage in the economic growth, an arithmetic mean of the neighbouring values representing numbers of development stages (e.g. in case of classification to stages 2–3, the mean equals 2.5) was applied as the value of the grouping characteristic. The analysis did not take Romania into account as the Gauss-Newton algorithm will not achieve convergence for the parameters of model (3) estimated for this country. The results of groupings are presented in Figure 2.

Figure 2 Dendrogram of the grouping of the countries of Central and Eastern Europe with the use of Ward's method due to the level of economic growth by economy sectors



Source: Own elaboration

The optimal number of clusters was determined with the use of the criterion of the first distinct increase in agglomerative distance (Sokołowski, 1992) by obtaining the following groups of countries similar in terms of the course of the investment development path in various economy sectors:

- group 1: Latvia, Estonia,
- group 2: Hungary, Slovenia, Slovakia, Poland, Czech Republic,
- group 3: Lithuania, Bulgaria.

The degree of diversification of the created groups and the "ability" of the grouping variable to diversify the created groups, i.e. the level of economic growth in individual sectors, were evaluated with the use of a single-factor analysis of variance and the results of this analysis are presented in Table 7. It contains aggregated levels of economic growth in the featured groups of countries and p-values of a single-factor analysis of variance ANOVA.

Table 7 Results of a single-factor analysis of variance ANOVA by economy sectors

Economy sector	Average values in groups			*p*-value
	1	2	3	
Agriculture	1.00	3.10	2.50	0.0041
Processing industry	2.50	3.40	1.75	0.0458
Construction	1.75	3.10	2.50	0.2038
Services	1.00	3.20	2.50	0.0011

Source: Own elaboration

Table 7 suggests that countries categorised in the second cluster achieved the highest average level of development in each of the four economy sectors. Countries from the first group have the weakest result in the range of development in agriculture, construction and services. Countries from the third group, in turn, are characterised by the lowest level of development of processing industry. The analysis of Table 7 also suggests that economic growth of agriculture, processing industry and services contributed to the significant diversification of the created clusters while the development of construction did not considerably diversify the created clusters.

To present the current situation in the area of the economic development in compared countries the average GDP *per capita* (or GVA *per capita* by the sectors of economy), NOI *per capita* were calculated for the data from the period 2008–2012. Table 8 shows the values both for the whole economy and by sectors: agriculture, processing industry, construction and services. Taking into account the value of GDP per capita, it is clear that the strongest economies in recent years were the Czech Republic and Slovenia. However, the Slovenia seems to have a higher investment position, because it has a more advantageous ratio of NOI to GDP. In the light of the presented results in Table 8 Slovakia and Bulgaria have the weakest economies. They are characterized by relatively low values of GDP and relatively low values of NOI. In the agriculture sector, the highest economic position have Hungary and Romania. The manufacturing industry has the highest development in the Czech Republic, and in Slovenia. The highest level of construction development was recorded in Slovenia and the Czech Republic.

Table 8 The average GDP, GVA and NOI per capita in years 2008–2012 (in euros) in the countries of Central and Eastern Europe

Country	Whole economy		Agriculture		Processing industry		Construction		Services	
	GDP	NOI	GVA	NOI	GVA	NOI	GVA	NOI	GVA	NOI
Bulgaria	3 931.1	–3 872.8	220.6	–18.5	923.6	–621.0	320.6	–285.6	2 466.2	–2 815.7
Czech Republic	13 871.7	–6 791.6	339.6	–12.7	4 374.5	–2 625.3	944.7	–44.9	8 187.2	–3 470.2
Hungary	9 474.5	–4 723.9	399.4	–33.5	2 444.7	–1 333.7	466.8	–55.0	6 163.5	–3 017.0
Estonia	9 745.6	–5 217.5	300.9	–61.2	2 027.5	–1 038.1	910.3	–70.9	6 099.9	–3 240.5
Latvia	7 763.2	–3 216.3	238.9	–67.8	1 057.6	–358.4	640.1	–59.7	5 826.5	–2 317.9
Lithuania	7 680.3	–2 288.8	308.3	–21.1	1 771.5	–467.4	746.6	–33.3	4 853.9	–1 476.3
Poland	9 141.0	–2 528.1	320.5	–14.2	2 177.7	–869.0	607.2	–51.7	6 035.6	–1 545.0
Romania	5 647.6	–2 167.1	347.1	–20.2	1 545.0	–692.5	604.2	–29.4	3 151.3	–1 189.5
Slovakia	3 018.0	–6 302.7	36.0	–11.6	1 060.8	–2 176.0	656.9	–168.3	1 247.5	–2 870.9
Slovenia	13 692.2	–2 499.4	126.9	10.3	3 763.6	–817.3	1 012.6	14.8	8 589.0	–1 689.0

Source: Own study based on Eurostat data

We note, Slovenia shows the highest investment competitiveness in terms of NOI position. Also, the Czech Republic and Slovenia in the services sector have received the highest GVA, which may indicate a relatively high level of development of this sector in both countries. Of course, the complexity of business processes is so high that the same measure of GDP (or GVA) *per capita*, NOI *per capita* are certainly not sufficient to fully assess the economic and investment position of individual countries. In the discussion on the economic position of countries it should be taken into account the sources of comparative advantage of economies, the level of technological advancement, the quality of human capital and other factors (Grossman, Elhanan, 1993, Stokey, 1991, Woźniak, 2008). However, J. H. Dunning (1981) built his theory of economic development on based two variables only: GDP *per capita* and NOI *per capita* so these variables were the basis for the verification of this theory of economic development in this article.

This description of the economic situation with GDP (or GVA), NOI *per capita* is obviously static, which significantly hinders the identification of the economic development stage. The proposed approach in this paper is free from these limitations.

CONCLUSION

The approach to the examination of relations between the level of NOI *per capita* and the level of GDP *per capita* proposed in this article in the context of the verification of J. H. Dunning's theory of economic growth seems to be an interesting alternative for the most frequently applied solutions in this field. So far, the most frequent method of examining the investment development path involves the polynomial models of regression describing the dependence between NOI and GDP. Even though they enable the approximation of the examined dependence, they also have several important limitations. First of all, it is difficult to give substantive interpretation to parameters in such models, which does not allow for specifying unambiguously the stages of the country's economic development and for stating whether an investment development path expires or develops.

The proposed model using the operating mechanism of a harmonious oscillator seems to cope well with these difficulties. An elementary advantage of this model is an easy interpretation of its parameters, which enables the creation of simple rules of allocating a country to a specific stage of economic growth. The proposed approach makes it also possible to model the path of investment development in the dynamic perspective and the analysis of its fluctuations allows for evaluating the degree of convergence or divergence as well as the length of the very investment cycle. Classical polynomial regression models did not give such possibilities in the range of the analysis of the investment development path. It should also be added that potential difficulties of numerical character connected with the estimation of the proposed harmonious oscillator model are relatively easy to overcome with the use of suitable computer packages with the programmed Gauss-Newton algorithm.

The sector perspective of the problem of economic growth proposed in this paper allowed to go beyond classical frameworks of J. H. Dunning's model of economic growth. The decomposition of economy into basic sectors allows for determining their contribution into economic growth (by measuring the added value generated by them). For this reason, sector perspective of the issue of economic growth seems to offer wider outlook on the economic development than it is possible from the perspective of the economy as a whole.

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Future Skilled-Labour Markets in Germany: from Model-Based Calculations to Scenarios

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Abstract

In this article, we focus on the potential development of the German labour market. For this purpose, we developed a forecasting system that considers both supply and demand by occupational fields and qualifications and that relies on consistent datasets, exogenous assumptions and systematic correlations. We present the key impacts for our forecasting system and highlight the effects of different assumptions (scenarios) exemplified on our demand model. On the supply side, we point out how different behaviours on the individual level influence the structure of development of the supply of skilled labour. Keeping the possibility of those various potential futures in mind, we conclude with an outlook on potential skilled labour shortages in the future.

Keywords

Employment, qualification, forecast, scenario building, occupational mobility, demography, labour market

JEL code

J11, J21, J32, J40, J62, E27

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INTRODUCTION

The labour market of the future is very difficult to grasp from today's standpoint except through the lens of model-based analysis. Then again, we have to be aware of the fact that there is not just one exclusive future to be expected. Instead, each point in time, there are many decisions that could possibly be made that lead to a different outcome. One way to handle this in model-based analysis is through a calculation of scenarios. Scenarios must represent futures that are internally consistent and leastwise possible. Significant conclusions can be drawn from a quantitative approach combined with qualitative knowledge. Instead of hoping that matters will resolve themselves, it emerges that every individuals' choices count: people make the difference. For the benefit of individuals and the community as a whole, it is necessary to analyse education and workforce participation, continuing education and dropout rates with the utmost precision.

Although it is mainly the shortage of skilled workers in the MINT occupations (mathematics, IT, natural sciences and technology) that has penetrated the awareness of the interested public, little is generally said about the equally, if not far more, significant problems in the sphere of initial vocational education and training (IVET). This is precisely where the calculations of the QuBe project on qualifications and occupations (Qualifikation & Beruf, <www.qube-projekt.de>)[5] reveal shortages in the future.

The article is structured as follows. First, we face the fact that there will not only be one specific future that will come true which formulates certain requirements to a model system for the labour market. After explaining the assumptions that drive our model, we first focus on the method and results on the demand side and thereafter present the influencing drivers of the supply side. We finally compare the results on the demand side with the results on the supply side and conclude with implications for practice and an outlook on further model development. The text of this article is mainly based on presentations given during the VDSt (Association of German municipal statisticians) Scenario Workshop at the "Statistische Woche 2012" conference.

1 LIVING WITH DIFFERENT FUTURES

In the sustainability debate, looking into the future means anticipating the usual because only in years to come it will be clear whether our efforts today to save energy, conserve resources and develop technologies were actually successful. For instance, the Stiglitz, Sen, Fitoussi Commission (2008) also correctly infers that projections are necessary, rather than relying on current observations alone, in order to evaluate the actions we take today.

Our view of the future is impeded, however: we do not know the realities of important determinants of our future action and opinions differ about the correct way to model our reactions to them. We must think in terms of the alternative options and leave room for falsification by disclosing the underlying assumptions.

To this end, it is necessary to identify the important exogenous determinants and to combine them consistently in the context of scenarios. Apart from demography, these determinants include the assessment of economic development in other countries and the movements in important commodity prices. A further issue is that of selecting the "correct" model. In the following, the way from the scenario to the model-based calculation is discussed with reference to the QuBe project (Helmrich, Zika, 2010, Helmrich et al., 2012, <www.qube-projekt.de>).

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[5] The QuBe project is a collaboration between the Federal Institute for Vocational Education and Training (*Bundesinstitut für Berufsbildung – BIBB*), the Institute for Employment Research (*Institut für Arbeitsmarkt- und Berufsforschung – IAB*), the Fraunhofer Institute for Applied Information Technology (*Fraunhofer-Institut für Informationstechnik – FIT*) and the Institute of Economic Structures Research (*Gesellschaft für wirtschaftliche Strukturforschung – GWS*).

1.1 Requirements for a model-based analysis of the future

In many cases, today's action on the labour market is regarded with uncertainty as to the effects of that action in the medium- to long-term future. At the same time, today we can already anticipate certain future changes (demography, the global shift in economic significance) which necessitate action now. Above all, questions of sustainability on the social, ecological and economic dimension require us to "look into the future". But to do this, a model has to fulfil certain requirements, namely an integral and simultaneous view as well as consistency, transparency and interdisciplinary.

The work of the QuBe project takes an *integral* (not just the labour market but the economic development as a whole; not just dual system but also university-based IVET) and hence a *simultaneous* approach. Changes in the labour market, for example, affect income generation (wage income) but also consequently the spending of income (the consumption of private households). Households' consumption choices, in turn, have an effect on the labour market.

For reasons of *consistency*, a standard dataset for labour market activity is used. The data are based on the German Microcensus (German Labour Force Survey) and are adapted to the parameters of the German Federal Statistical Office's national accounts. This is the only feasible way to put the development of the labour market into the context of the economy as a whole.

Furthermore, the principles of *transparency* and *interdisciplinarity* are put into practice: the project is based on the expertise of occupational researchers, social scientists and economists, who evaluate the results extensively in an open dialogue and cooperate fully in reporting the findings. This is especially important when specific occupations and sectors are analysed (see e.g. in the Building sector Weiss, Rehbold, 2012, Maier, Thobe, 2012).

1.2 How does the future look? Components of the QuBe reference scenario

To aid an understanding of the route from our research aspirations to the completion of the results, the components of the QuBe reference scenario are described below: these consist of (1) *datasets*, (2) *exogenous assumptions* and (3) *systematic correlations* in the form of definition and behavioural equations. These three elements will now be examined.

Two important components of the *dataset* are the German national accounts and the population projections and estimates of the Federal Statistical Office. With historical data in general, we find ourselves to be on safe ground. After all, the past is completed and hence known. The reality, however, is somewhat different. On occasions, gross domestic product (GDP) undergoes notable corrections. For instance, the growth rate for 2010 was corrected in September 2012 from 3.7 to 4.2 per cent. Currently 0.5 per cent corresponds to more than €10 billion, quite a windfall. Population development in the past is likewise a matter of considerable uncertainty: today it has been 25 years since Germany's last census; since then population figures are extrapolated. Since the results of the extrapolation are used in population projections, even the 12th Coordinated Population Projection of the Federal Statistical Office is burdened with more than the usual uncertainties. Only the results of the 2011 census and the subsequently produced 13th Coordinated Population Projection will shed light on the necessary correction. Particularly for cities and municipalities, these projections are of decisive importance for political action.

The list could be continued: what is certain is that even the past can be a puzzle for us. It is therefore of critical importance to be certain of our data and to document clearly how it was compiled when looking at the future.

The *exogenous* assumptions of the QuBe project are specified up to the time horizon of 2030. Because of Germany's high share of exports and great dependency on raw materials, important parameters for the dynamics of the German economy relate to development on global markets. In order to be able to set parameters for the petroleum price, reference is generally made to the annual World Energy Outlook of the International Energy Agency (IEA), which provides oil-price projections up to (most recently) 2035.

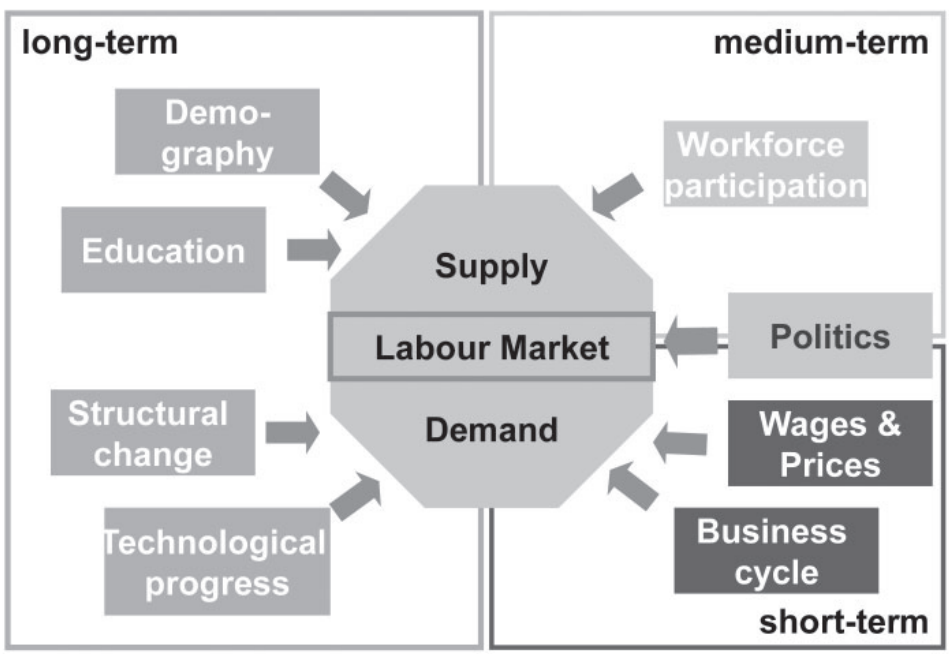
A look at the history of oil price projections shows that assessments of the 2030 oil price have changed considerably between 2004 and today. Whereas not quite 10 years ago it was still assumed that oil prices would be approximately $50/barrel in 2030, today's assumption for the same year is around $210/barrel. So we have to bear in mind that assumptions for exogenous impacts are also burdened with considerable uncertainties.

It is worth stating as an *interim conclusion* that in the setting of a fluctuating past, any assumptions we work with when constructing a model are very volatile. This insight is not peculiar to QuBe: no model-based calculation or other type of *statement* about the future – whether quantitative or qualitative – is *unaffected* by the stated considerations.

How can they be dealt with? Researchers are left with no choice but to make a selection with regard to data and assumptions and to document this clearly. By means of scenario calculations, consequences of modified assumptions can then be determined and the corridors of developments mapped out. Sensitivity calculations make it possible to gauge the influence exerted by assumptions, particularly on the object of the research. A description of the system and transparency are absolutely essential. As part of the QuBe project, scenario calculations have already been produced on behalf of the Federal Ministry of Education and Research (*Bundesministerium für Bildung und Forschung* – BMBF). Furthermore, the impacts of globalisation on the German labour market have been studied (Mönnig et al., 2013) and the costs of energy-efficiency refurbishment and construction in accordance with European Union targets have been calculated (Weiss, Rehbold, 2012, <www.bauinitiative.de>).

Finally, the results are substantially influenced by the correlations in the model, definition and behavioural equations. Against the background of the labour market being examined here, the question is which contents need to be modelled.

Figure 1 Which correlations must be modelled? Varying time-frames and intensities



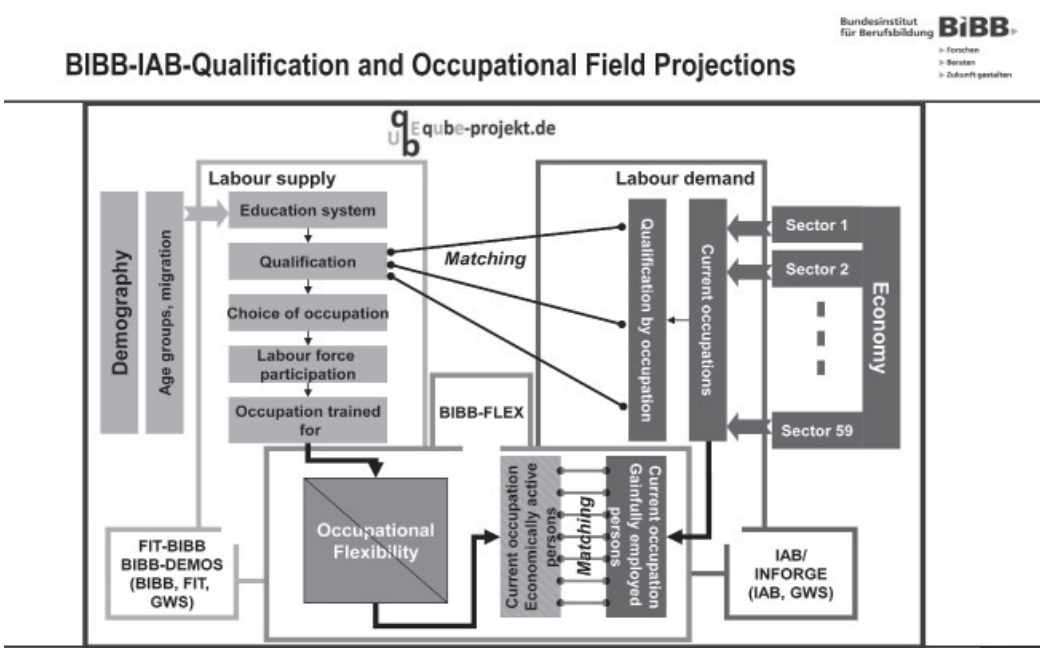
Source: QuBe-Projekt

The correlations vary particularly in their time-frames and in the magnitude of their effects (see Figure 1). Demography and education modify the labour market supply in the long term. Economic structural change and technological progress do the same on the demand side. In terms of magnitude of their effect, these four variables are very different. In the medium term, a change in workforce participation can affect the supply side considerably. The current developments of salaries as well as economic cycles have an influence on the demand side in the short-term. Politics is usually geared towards the short and medium term. An important example from the recent past is the expansion in temporary employment as a state of affairs during the economic and financial crisis.

What is certain is the consequences for economic growth cannot be determined by "acute thinking". Based on these considerations, we formed the view that qualitative models alone are not sufficient and therefore opted for a quantitative approach. Quantification of a model requires underpinning it with some empirical foundations, however, to avoid producing a mere "thought experiment". Moreover, this highlights important characteristics that the quantitative model must fulfil.

(1) It must model precise dates because it is critical for the evaluation of undesirable developments on the labour market to know not only "whether" but also "when".
(2) It must be calculated in absolute figures in order for supply and demand to be comparable.
(3) It must model different forms of structural change: Transitions (population – education – workforce participation) are to be captured in detail and changes at sector level taken into account, since scarcity is not revealed in the aggregate but in the segments of the labour market.
(4) It must be able to represent options for political action (e.g. social contributions, state expenditures, pension age of 67).
(5) It requires empirical foundations.

Figure 2 QuBe project – an overview



Source: Helmrich et al. (2012)

An introductory look at the QuBe project is given by the highly simplified diagram in Figure 2. The labour market is determined substantially by two concurrent processes: demography (green) and economic structural change (blue). While the supply of people available to the labour market, starting in the population and progressing through the education and training system to workforce participation is counted in terms of "occupation trained for", companies in the various sectors are exposed to shifting competitive opportunities or technological change and therefore state their demand in terms of "occupations held". These two sides would stand in juxtaposition without any prospect of reconciliation if occupational flexibility (orange), which stems from the willingness of both sides of the labour market to adapt, were not taken into account. In the following, we will describe the construction and the results of the demand model; thereafter we present the influencing drivers of the supply side and finally oppose the results on the demand side with the supply side.

2 CHANGING NEEDS: WHAT KIND OF WORKERS WILL BE IN DEMAND IN THE FUTURE?

The updated BIBB-IAB Qualification and Occupational Field Projections extrapolate observable developments in the German education system and labour market. Nevertheless, it is not only possible but also likely that future developments will deviate from past patterns. It is therefore sensible to point out various alternative development paths. One basis for alternative calculations might be, for example, political objectives along with the assumption that the labour market might respond with anticipatory adaptations.

In order to give an impression of the underlying complexity, we briefly look at a more detailed representation of the economy. It is represented within the QuBe project by the INFORGE model of the Institute of Economic Structures Research (GWS); the labour market of the model is adapted to the necessities of this project in close cooperation with the Institute for Employment Research (IAB). INFORGE (*Interindustrie Forecasting Germany*) is an econometric model operated since the beginning of the 1990s which models the development of the German economy based on the official system of national accounts of the Federal Statistical Office. The established model (e.g. EUROSTAT, 2008, pp. 527ff) is fully documented (Distelkamp et al., 2003, Ahlert et al., 2009) and is used in many projects for different clients (including e.g. the German Savings Banks Association or the Federal Ministry of Economics and Technology).

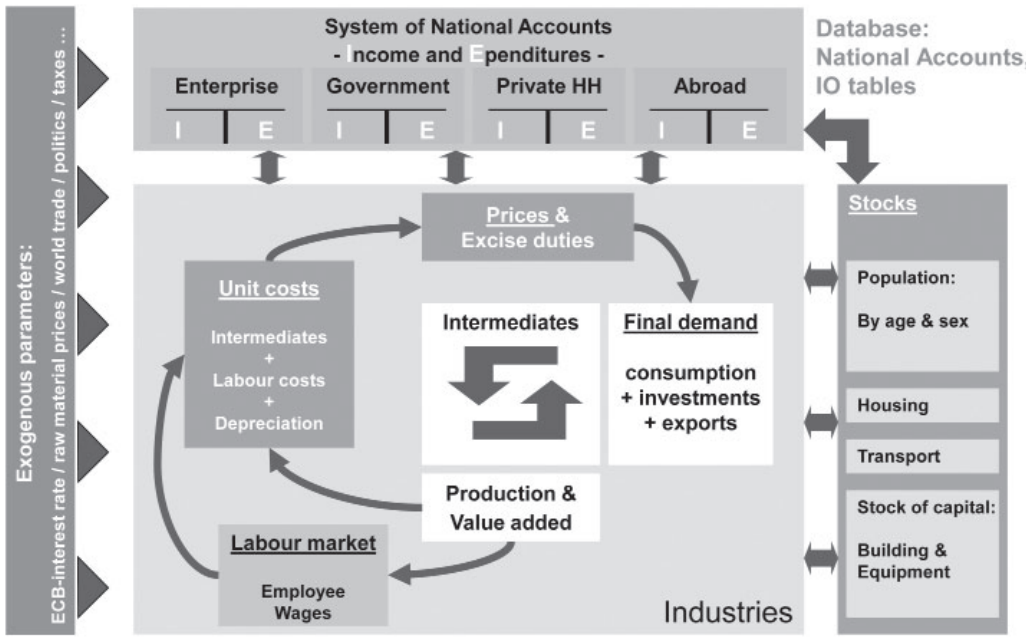
2.1 Modelling the demand side

Starting from exogenous parameters and taking account of important stock variables, the developments of economic branches are modelled. At the core, the branches are interlinked through their supplies of inputs to each other. Production and value creation, determined for every branch, exert an influence on the labour market and on price formation via unit cost calculation. The aggregates are entered in the national accounts system. Consistency remains assured only by virtue of double bookkeeping.

On the basis of the projection of sectoral structural change by the IAB-INFORGE model and the extrapolation of long-term trends in the development of demand within the sectors by qualification and occupation, a projection of labour demand by qualifications and occupations in Germany up to 2030 can be derived (Hummel et al., 2010, Zika, 2012).

The entire project, of which this is only a superficial description, provides the tool for generating the QuBe reference scenario. This can be described as a continuation of the correlations and changes identified in the past whilst maintaining consistency. That is to say, revenues and expenditures are identical with reference to the economy as a whole, and every individual as a part of the population is captured. The rising trend in workforce participation rates of women and older people continues, as does the progressive advancement in qualification levels of women. Moreover, previously agreed political interventions whose effects will continue into the future, like the pension age of 67, are implemented.

Figure 3 IAB/INFORGE



Source: QuBe-Projekt

The reference scenario serves as a starting point for sensitivity and scenario calculations. Whereas a sensitivity calculation only gives information about an isolated intervention in the model (e.g. increase in world trade, see Maier et al., 2012), scenarios represent several interrelated interventions (e.g. accelerated energy efficiency refurbishment with part private financing, see Weiss, Rehbold, 2012). Sensitivity calculations thus give information about the properties of the model and the impacts of individual parameters. A scenario, on the other hand, describes a different but equally consistent and equally possible future.

The reference scenario described here relates to the period up to 2030. The assumption was made that the potential economically active population would fall by around 3.7 million people compared to the year 2010, corresponding to a sizeable 8 per cent decline. An important control variable for the labour market is the development of annual working time. In the QuBe projection, a rise in annual working times was presupposed. Furthermore, moderate pay growth and a rise in exports and imports were assumed in the course of the recovery and advancing globalisation of the world economy.

That is the kind of scenario that emerges from the assumptions and from the empirically estimated behavioural parameters contained in the model. Accordingly, German GDP grows in the projection period by an annual 1.0 per cent if price-adjusted, and per-capita GDP by an annual 1.3 per cent in real terms. The model assumes that private consumption and state consumption will grow at below average rates (because of the 'debt cap'), resulting in continuing high levels of saving and investment. Under these – from the viewpoint of the labour market – cautiously optimistic assumptions, there would be a slightly declining demand for labour from companies. Under the model's assumptions, the number of people in employment would fall only moderately to 39 million by 2030. Underemployment would nevertheless continue to decline perceptibly because the supply of labour in the same period would fall markedly from 43.4 million to 40.0 millionpeople.

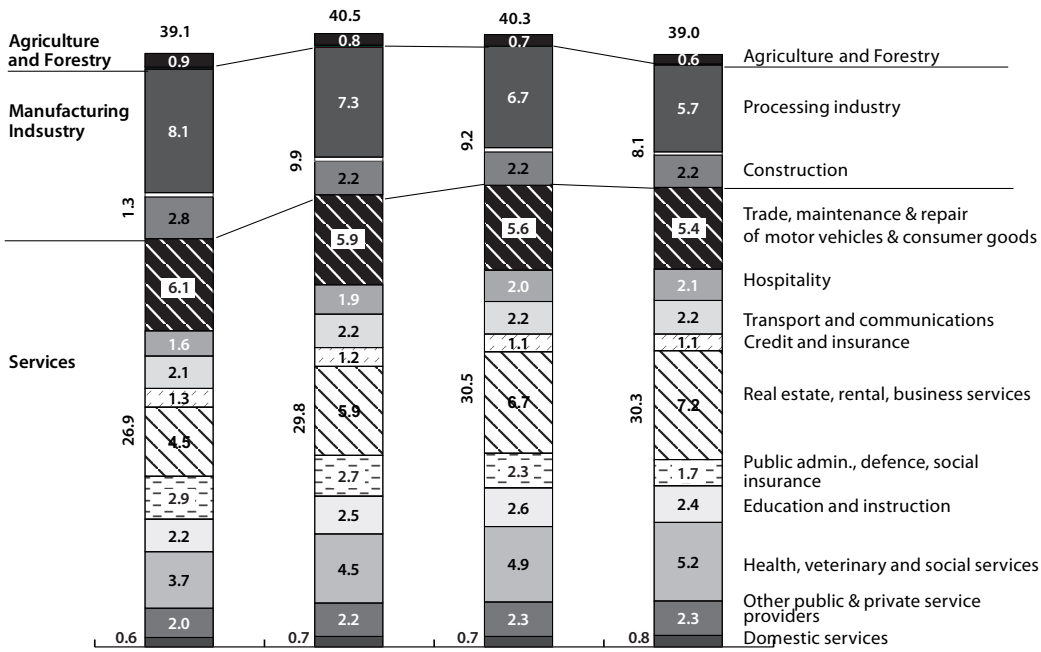
In the short term, workforce demand is strongly determined by the economic cycle, although the economic trend can certainly have varying effects on demand for individual qualifications and occupations. In the long term, the demand for labour depends on sectoral structural change and, within the sectors, on the changing demand for qualifications and occupations.

2.2 Demand by economic sectors

For the sectoral development of labour demand in hours, the projection confirms the fundamental tendencies of a persistent tertiarisation as already found previously. The significance of the service sector overall continues to grow (Hummel et al., 2010, cf. Figure 4).

However, it is unlikely that all branches of the services sector will increase to the same extent. Quite the opposite: high-productivity branches of the service industry such as "Trade, maintenance and repair of motor vehicles and consumer goods" require fewer and fewer employees. Likewise the sector of "Public administration, defence, social insurance" will need far less labour in future. In contrast, there is strong growth in the number of people employed in business services. This is partially due to practices, such as employee leasing, being expected to become even more significant in future. Additionally, the persisting process of outsourcing company units and business functions is likely to play a continuing role although this trend is declining. A very good employment outlook is also recorded in "Health and social services". The main reason for this, alongside the growing importance of childcare, is the ageing of society. As a result, on the one hand the demand for health services will rise enormously, and on the other hand employment will expand in institutions for the elderly and in outpatient care services (see also Maier, Afentakis, 2013).

Figure 4 Number of people in employment by sectors, 2000–2030, in millions

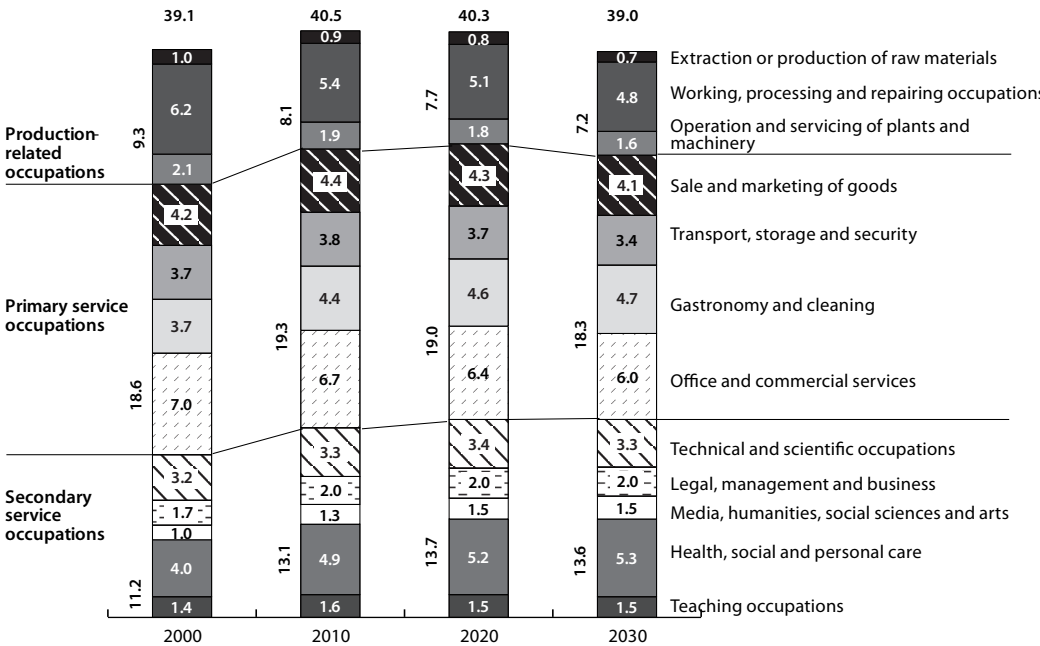


Source: Microcensus of the Federal Statistical Office; QuBe-Projekt

2.3 Demand by major occupational fields

The projection of workforce demand by major occupational fields, which reflect both occupations and core tasks (Tiemann et al., 2008), supplies an extrapolation of the developments that have been observable for a long time (cf. Figure 5). It can be assumed that the demand for production-related occupations will decline markedly. Likewise, the demand in the primary service occupations, namely in "Occupations involving the sale and marketing of goods", "Transport, storage and security occupations" and for "Office and commercial services occupations", will decrease. The only branch in which a constant rise is expected is in "Gastronomy and cleaning occupations". Within the secondary service occupations, the main area of growth is in the "Health and social care" occupations.

Figure 5 Number of people in employment by major occupational fields, 2000–2030, in millions



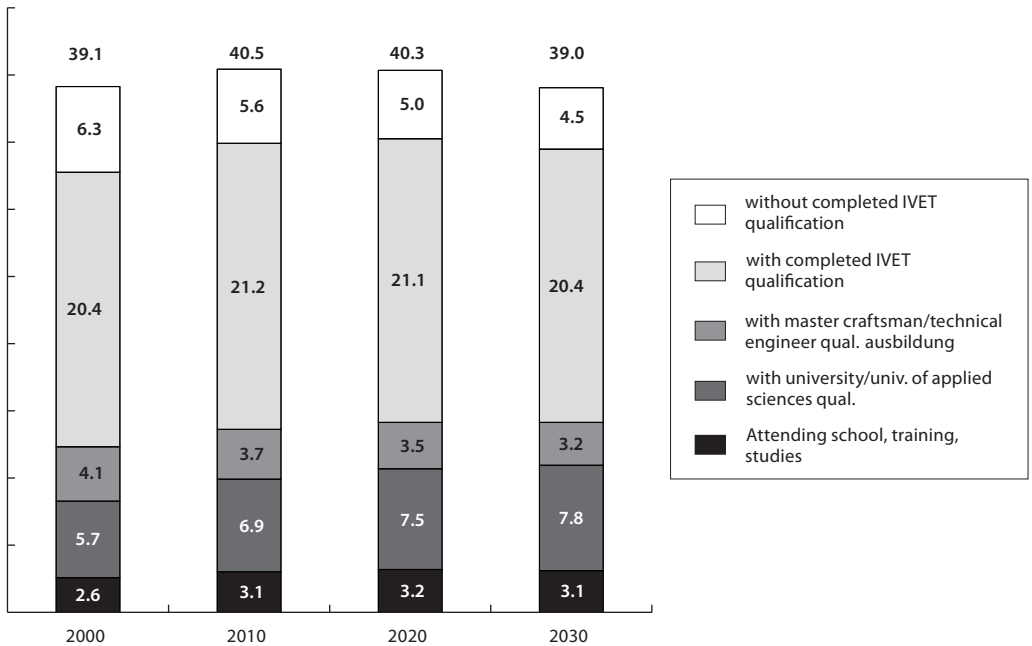
Source: Microcensus of the Federal Statistical Office; QuBe-Projekt

But, in this consideration of future developments, it is essential to bear in mind that these are highly aggregated "major occupational fields" (MOFs). The occupations grouped within them can exhibit divergent trends. For example, the major occupational field of "Technical and scientific occupations" comprises a total of 247 occupations (Tiemann et al., 2008).

2.4 Demand by qualification levels

The hypothesis of a trend towards higher qualification, which has received widespread publicity, is supported by the projection of workforce demand by highest vocational qualification (cf. Figure 6). Thus, it can be assumed that the number of working people in the services sector will continue to rise. This growth is based on sectoral development, on the trend towards more demanding occupations within the branches of the economy, and also on the fact that the formal qualification level (taken as indicator for the requirement level of tasks) within the occupational fields is steadily increasing.

Figure 6 Number of people in employment by qualification levels, 2000–2030, in millions



Source: Microcensus of the Federal Statistical Office; QuBe-Projekt

The demand for work performed by people with a qualification from a company-based apprenticeship or a full-time vocational school remains more or less constant up to 2020 and declining somewhat thereafter. This means that the dual system IVET or the corresponding school-based alternatives remain the dominant form of IVET in Germany.

Ever-diminishing demand is likely for workers who have not completed an initial vocational qualification. Wider-ranging analyses show that the decline in low-skilled work is almost entirely attributable to the tendency towards more demanding tasks within the occupational fields. This means that the driving force behind the falling demand for low-skilled work is not economic structural change, but rather technological and organisational change. Once again this underscores the significance of the share of unskilled workers for the labour market of the future.

Nevertheless, one glimmer of hope for the low-qualified still remains: the model-based calculations show persisting demand for work that is typically carried out by schoolchildren and students alongside their schooling or studies. Since the number of people in the education system is falling due to the demographic trend, in future it will not be possible to meet this demand fully. In this area, employment opportunities for low-skilled workers might potentially open up.

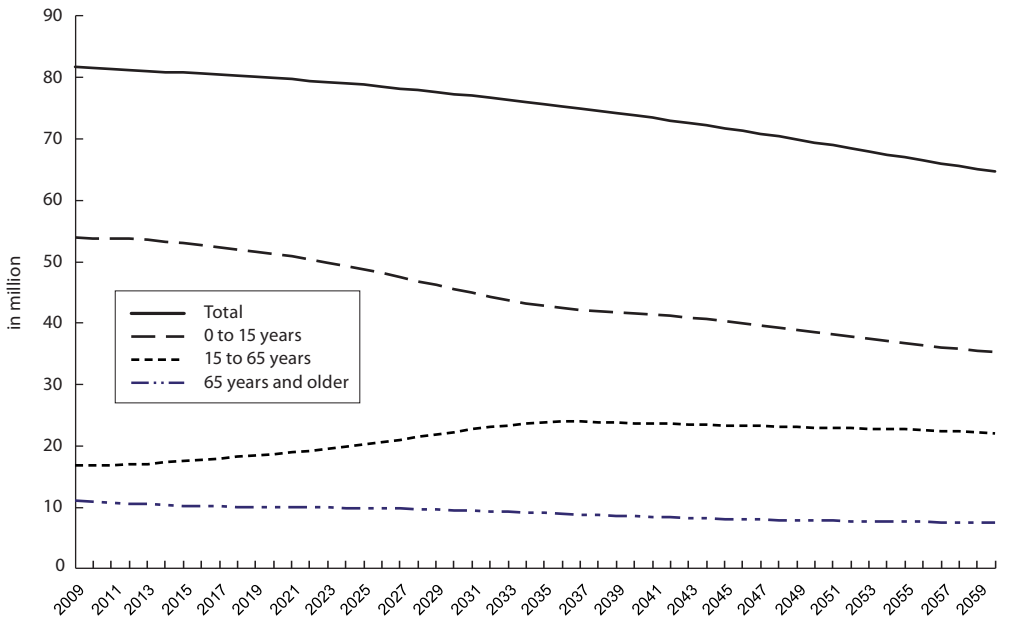
3 PEOPLE MAKE THE DIFFERENCE: ASSESSING FUTURE EDUCATIONAL AND EMPLOYMENT CHOICES

As mentioned in section 1.2, our reference scenario is based on past developments. Apart from the development of demand, the other main factor is the development in the supply of workers. Along with the demographic variables, the focus here is on the educational and employment choices made by individuals. In the following we will answer to the question: what are the consequences of economically active people's choices and courses of action for the supply of labour in the year 2030?

3.1 Germany up to the year 2030

Based on what is currently know n, the population of Germany is not only shrinking in the coming years, but also ageing (cf. 12. koordinierte Bevölkerungsvorausschätzung (12th Coordinated Population Projection), cf. Figure 7). This means that the demand for labour will gradually return to the 2008 level in the next few years, and will fall noticeably below the 40-million threshold by 2030 (cf. Helmrich et al., 2012), whereas the number of people who are 65 years and older is greater than the under-15 age-group and this disparity will widen. Progression of the high-birth-rate cohorts towards pension age in the coming years will result in a shift in the average age of the working-age population.

Figure 7 Population development overall and by age-groups



Source: Federal Statistical Office; 12th Population Projection – Variant 1-W1, presentation: Helmrich, Zika (2010)

Two variables dominate population development. One is the birth rate which is currently around 1.39 children per woman of childbearing age in Germany (source: Federal Statistical Office; the fertility rate necessary for a society to reproduce itself without immigration is around 2.1). Even if this should rise significantly in the next few years, the impacts on the labour market would be discernible in around 20 years at the earliest – i.e. long after 2030.

In recent years it was generally assumed that around 100 000 more people per year were migrating to Germany than were emigrating. After years of very low net immigration, this level has been significantly exceeded in the last two years (128 000 people in 2010 and close to 280 000 in 2011, a level last matched in 1996). In the long run, therefore, net immigration of between 100 000 and 200 000 could be realistic, and expected net immigration for 2012 supports these assumptions. The rate of population shrinkage will gather pace due to the growing number of mortalities in coming years (the high-birth-rate post-war years just now are gradually reaching pension age) and the continuing fall in the number of births (since today's and prospective parents were born after the demographic contraction associated with the oral contraceptive pill). This growing surplus of deaths over births can only be made up in the long term by immigration of more than 400 000 people per year. In the present projection, a positive migration effect

of 100 000 people per year (net immigration movements) was assumed. However, it is quite questionable where the additional immigrants should come from because the Eastern European nations, whose population typically migrates to Germany, are themselves suffering from massive population shrinkage. In the medium term, immigration is mainly expected to come from non-European regions like Asia or Africa (UN/DESA, 2011).

Table 1 Development of immigration and emigration

Year	Inward Migrations From abroad	Outward Migrations Abroad	Net Immigration Into Germany
2012°	1 081 000	712 000	369 000
2011	958 156	678 949	279 207
2010	798 282	670 605	127 677
2009	721 014	733 796	-12 782
2008	682 146	737 889	-55 743
2007	675 641	632 357	43 284
2006	661 855	639 064	22 791
2005	707 352	628 399	78 953
2004	780 175	697 632	82 543
2003	768 975	626 330	142 645
2002	842 543	623 255	219 288
2001	879 217	606 494	272 723
2000	841 158	674 038	167 120

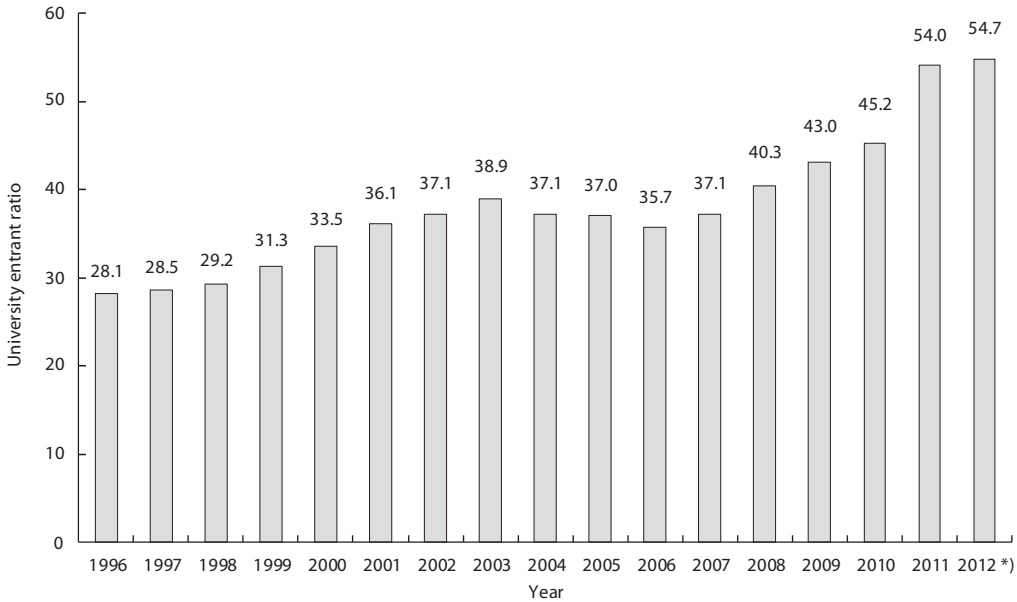
° Preliminary result.
Source: German Federal Statistical Office

The good news is that purely arithmetically; almost full employment could prevail by 2030. However, this is only true if the future demand for workers can be met not only quantitatively but also in terms of the right qualifications. While the rising demand for workers increases jobseekers' opportunities of finding employment, it also harbours the risk of a skills shortage in specific areas of qualification, branches or occupations. Therefore, education and employment patterns become even more significant.

3.2 Education patterns

Germany is currently undergoing an educational expansion. In 2010, the proportion of university entrants accounted for 45 per cent of an age cohort (Statistisches Bundesamt, 2012). Thus the proportion of those working towards an academic qualification has risen by more than 10 percentage points within 10 years (cf. Figure 8). The university entrant ratio of 55.3 per cent in 2011 is due to the double-cohort of upper secondary school leavers in Bavaria and Lower Saxony and is likely to be repeated in 2012 (double cohorts in Baden-Württemberg, Berlin, Brandenburg, Bremen and parts of Hessen) and especially in 2013 with the double upper secondary cohort in North Rhine-Westphalia and parts of Hessen. Thereafter the university entrant ratio will settle at a little under 50 per cent which is still twice as high as in 1995. While first-semester students are currently overcrowding university lecture rooms, the number of newly concluded training contracts is falling (cf. Figure 9).

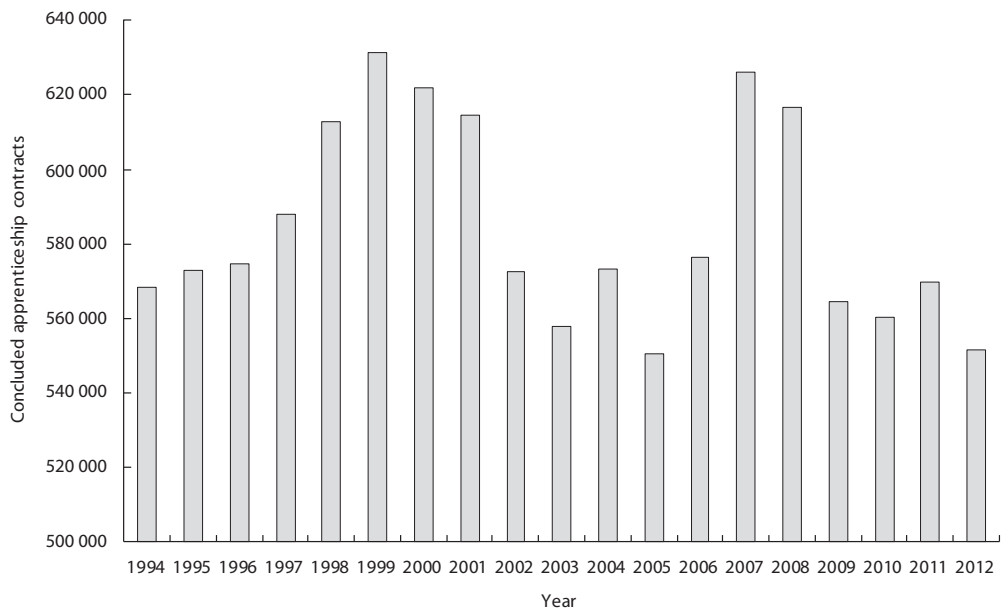
Figure 8 University entrant ratios from 1995 to 2012 (in %), university entrants as a proportion of same-aged population cohort



*) Provisional results.

Source: German Federal Statistical Office, 2012, Schnellmeldungsergebnisse der Hochschulstatistik, Vorläufige Ergebnisse (First release of higher education statistics, provisional results) – Winter Semester 2011/2012, presentation by BIBB

Figure 9 Initial vocational training market: Concluded apprenticeship contracts 1994 to 2010



Source: Federal Institute for Vocational Education and Training (BIBB)

The educational development trend is moving unmistakably towards an academisation of the German vocational training sector. At the same time, no trend reversal seems to be in evidence at the other end of the qualification trend, i.e. among young people without a formal qualification (cf. Braun et al., 2013). The rate of unqualified individuals remains constant, as it has for years, at 14.0 per cent of 20- to under 24-year-olds and 14.5 per cent of 20- to 34-year-olds.

Table 2 Development in the shares of unqualified individuals by age-group

	20- to 24-year-olds	20- to 29-year-olds		20- to 34-year-olds	
	Unskilled ratio in %	Unskilled ratio in %	Absolute (in millions, extrapolated)	Unskilled ratio in %	Absolute (in millions, extrapolated)
1996	14.8	14.6	1.57	14.7	2.59
1997	15.1	14.6	1.50	14.3	2.54
1998	15.1	14.7	1.45	14.1	2.34
1999	14.8	14.7	1.40	14.6	2.37
2000	14.4	14.4	1.32	13.9	2.17
2001	14.3	14.5	1.32	14.1	2.15
2002	15.1	15.2	1.37	14.6	2.20
2003	14.6	14.9	1.36	14.6	2.15
2004	14.5	14.9	1.37	14.3	2.05
2005[1)]	16.5	16.5	1.57	16.9	2.40
2007	14.5	15.2	1.45	15.3	2.24
2008	15.3	14.9	1.46	14.9	2.16
2009	14.1	14.6	1.44	15.2	2.21
2010	13.9	14.1	1.39	14.7	2.15

[1)] Due to a change in survey method, results of the Microcensus from 2005 onward are only comparable with previous years with reservations.
Source: Federal Statistical Office, Microcensus 1996 to 2009, calculations of the Federal Institute for Vocational Education and Training (Braun et al., 2013, p. 291)

Table 3 Continuing vocational education and training (CVET)

		1996	2000–2002	2007
15 to 24 years		5.6	5.1	4.8
	low (ISCED 0–2)	2.0	1.7	1.6
of which qualif. level…	intermed. (ISCED 3–4)	6.1	5.8	4.9
	high (ISCED 5–6)	10.4	8.0	11.2
25 to 34 years		6.2	5.5	6.8
	low (ISCED 0–2)	1.6	1.1	1.4
of which qualif. level…	intermed. (ISCED 3–4)	5.8	5.1	5.4
	high (ISCED 5–6)	9.8	8.4	11.9
35 to 44 years		3.8	3.2	5.8
	low (ISCED 0–2)	1.3	0.8	1.0
of which qualif. level…	intermed. (ISCED 3–4)	3.0	2.5	4.2
	high (ISCED 5–6)	6.6	5.5	11.1
45 to 54 years		2.6	2.2	5.2
	low (ISCED 0–2)	0.9	0.7	1.1
of which qualif. level…	intermed. (ISCED 3–4)	1.9	1.5	3.4
	high (ISCED 5–6)	5.1	4.2	10.8
55 to 64 years		1.4	1.1	3.9
	low (ISCED 0–2)	0.3	0.3	0.7
of which qualif. level…	intermed. (ISCED 3–4)	1.0	0.7	2.1
	high (ISCED 5–6)	3.0	2.4	8.7

Source: Leszczensky (2010, p. 120)

In 2010, around 1.4 million people aged between 20 and 29 years, or 14.1 per cent, held no formal qualification. Extending this age-group to encompass the 30- to 34-year-olds, the share of individuals without formal qualifications among 20- to 34-year-olds is somewhat under 15 per cent, around 2.2 million people in absolute terms. Over the course of life, this gap widens even more. Since 1996, the low participation in continuing education by women and those with low qualification levels mean that existing disparities in educational level have increasingly been amplified by continuing education.

Aggregating these developments and extrapolating them into the future, the supply of academically qualified new entrants to the workforce shows both a proportional and absolute rise in numbers, whereas the supply in the intermediate-level qualification segment declines both proportionally and in absolute terms. Regarding the share of unqualified people currently, this still must be assumed to remain rather constant into the future.

Table 4 New supply of economically active people not in training, by qualification levels

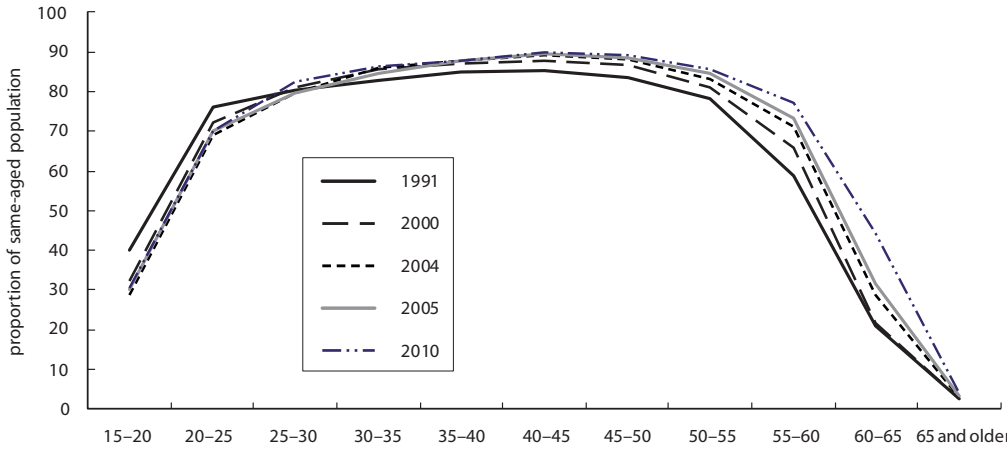
Period	without completed IVET qualification (ISCED 1, 2 & 3a)	with completed IVET qualification (ISCED 3b & 4)	Trade & tech. School, master/ tech.eng. qual. (ISCED 5b)	academic qualification (ISCED 5a & 6)	Total
	Cumulated new supply of economically active people in 1000				
2010	0	0	0	0	0
2015	559	2 106	334	1 100	4 098
2020	1 041	3 860	699	2 368	7 968
2025	1 536	5 468	1 108	3 670	11 781
2030	2 078	7 007	1 508	4 912	15 504
	New supply of economically active people in 1000				
2010–2015	559	2 106	334	1 100	4 098
2015–2020	483	1 754	365	1 268	3 870
2020–2025	495	1 608	409	1 302	3 813
2025–2030	541	1 539	401	1 242	3 723
2010–2030	2 078	7 007	1 508	4 912	15 504
	in per cent				
2010–2015	13.6	51.4	8.1	26.8	100
2015–2020	12.5	45.3	9.4	32.8	100
2020–2025	13.0	42.2	10.7	34.1	100
2025–2030	14.5	41.3	10.8	33.4	100

Source: Helmrich et al. (2012)

3.3 Employment patterns

Since 2000, the workforce participation rate, particularly among older people and women, has risen continuously (cf. Figure 10), partially compensating for the demographically induced decline in the supply of labour. A further increase in the coming years can be justified by the tendency for higher rates of workforce participation among the academically qualified and the increasing numbers of people with academic qualifications in future years. To reflect this, the QuBe project also assumes a rise in workforce participation.

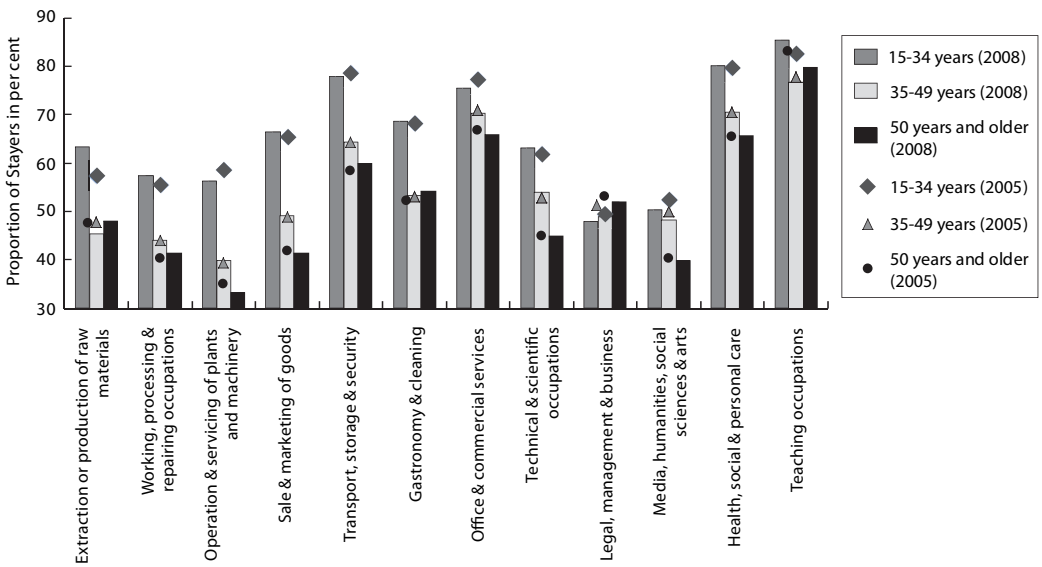
Figure 10 Workforce participation rates by selected age-groups (1991 to 2010)



Source: Microcensus of the Federal Statistical Office; Helmrich et al. (2012)

Staff recruitment shortages, experienced by companies, are rarely a problem of the applicants' qualification levels however and have far more to do with their concrete, job-specific qualifications and competencies. The BIBB-IAB Qualification and Occupational Field Projections therefore also compare the matching of supply and demand on the level of 12 BIBB major occupational fields (MOFs). The attribute of occupational field denotes a cluster of tasks specific to each occupational field. Occupations are homogenous with reference to the tasks within the occupational fields and heterogeneous between occupational fields. Herewith we try to capture the rather occupationally segmented and stratified German labour market in regard to other European Labour markets or the US labour market (Allmendinger, 1989).

Figure 11 Age-dependency of staying in the occupation trained for



Source: Microcensus of the Federal Statistical Office; own calculations

Above all, the occupations that operate in a restrictive labour market and only have limited recruitment options will have to take care not to lose their potential skilled workers to other occupations. In this way, the proportion of "stayers" in the individual occupational fields – i.e., individuals still working in the occupation they trained for – declines progressively with rising age. In the first few years after qualifying in a "Health and social care" occupation, around 80 per cent of appropriately qualified individuals still work in that sector, compared to only 70 per cent in the 35- to 49-year-old age-group and just 65 per cent in the over-50 age-group (cf. Figure 11).

Besides measures to increase population figures (rising birth rates and more immigration) and the necessary recognition of qualifications obtained abroad, it is mainly measures of education policy which are called for in order to meet qualification needs. The aim is not a one-sided increase in the numbers of graduates, as the OECD urges, but primarily a reduction in the numbers of school-leavers without a formal qualification and in drop-out rates both in the vocational and the academic segments (cf. Maier et al., 2012). A further imperative is to foster the attractiveness of vocational education and training and second-chance qualification also for older economically active people (including those with non-formal qualifications). Young people with 'poor' starting conditions especially should be brought to the point of achieving a vocational qualification and the availability and take-up of continuing education and advanced vocational training opportunities should be increased.

4 MATCHING DEMAND AND SUPPLY. WHEN WILL THE SKILLS SHORTAGE OCCUR – OR WON'T IT COME TO THAT?

Based on the reference scenario of the QuBe, we will now compare the projection of demand for employees with the projected supply of economically active people. . On the occupational level this is possible because an occupational flexibility matrix is part of the analysis. As mentioned above, this flexibility matrix transforms the supply of trained labour into a potential supply of people for specific occupations (Maier et al., 2010). This potential supply of labour for a specific occupation can subsequently be compared to the demand of labour in this specific occupation.

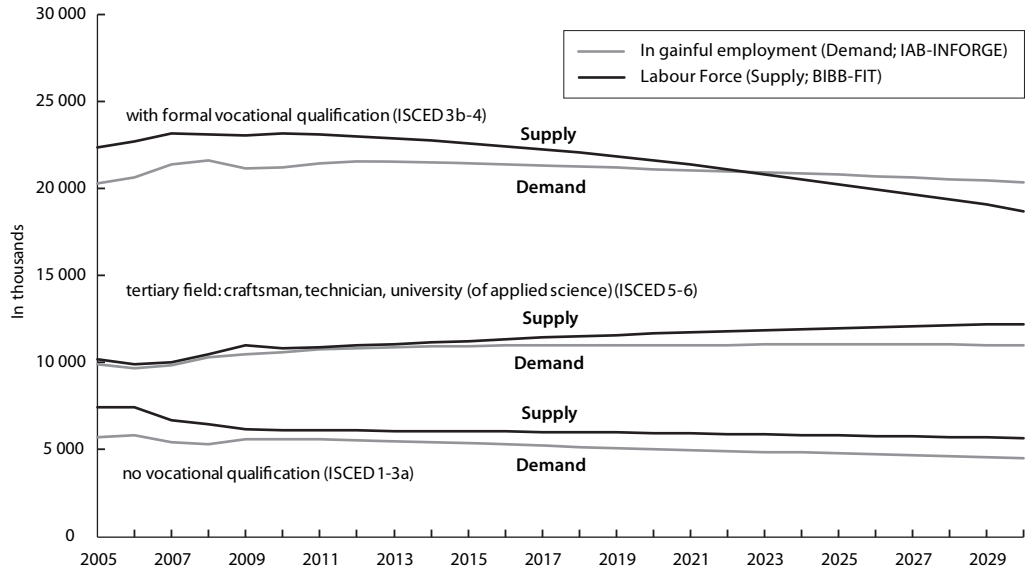
4.1 On the level of qualification levels

The supply of individuals with a completed initial vocational qualification will fall primarily for demographic reasons and, provided that patterns remain stable on the workforce demand side, will no longer fully meet demand towards the end of the projection period (cf. Figure 12). Even before that point in time, a rapidly growing skilled-worker shortage will be confronted at this qualification level, mainly because supply will not match demand, particularly from the viewpoint of job specialisation. The demand for skilled workers with a completed vocational qualification will only fall minimally which will mainly be attributable to the wage increases that become achievable due to shortages in the labour market (c.f. Helmrich, 2012, Maier et al., 2012).

In the tertiary sector, both supply and demand will continue to rise – they are already quite close together today. Among university graduates, the expected demand is made up of replacement demand and new demand induced by economic structural change in roughly equal shares. Replacement demand will grow very markedly from the end of the second decade (from 2020) as the high-birth-rate cohorts (known as the "baby boomer generation") approach retirement. The slight oversupply of graduates is based on the current tendency towards more academic qualifications. Growth in this area has picked up momentum in recent years, while growth in company demand is rising but not in the same order of magnitude.

At this point, adaptation and equilibrium processes with the intermediate qualification segment can be expected. Bachelor degrees should be especially affected by this, but no adequate empirical data is available yet on their opportunities and destinations in the labour market.

Figure 12 Labour force (supply) and number of people in gainful employment (demand) by qualification 2005–2030, in thousands



Source: Helmrich et al. (2012)

The demand for workers without a completed initial vocational qualification will fall slightly. For its part, the corresponding supply will diminish somewhat more slowly which will slightly augment the existing oversupply. Thus, the labour market offers no improvement in their employment opportunities to this group of people, even in future. Nevertheless, this is an obvious opportunity for early intervention, particularly to help new entrants and younger members of the economically active population, e.g. through second-chance training programmes to unlock potential at the intermediate skilled-worker level.

4.2 Supply-demand analysis by major occupational fields

Provided that vocational training patterns continue to develop under status quo conditions, a few major vocational fields will experience a massive workforce shortage as early as 2030, whereas others are characterised by a supply surplus (cf. Figure 13).

According to the findings, a supply surplus in the following occupations is expected:

- Occupations involving the operation and servicing of plants and machinery (MOF 3),
- Office, commercial, service occupations (MOF 7),
- Legal, management and business occupations (MOF 9).

A strained labour market situation is arising in the following major occupational fields even though projected supply still meets demand in purely arithmetical terms:

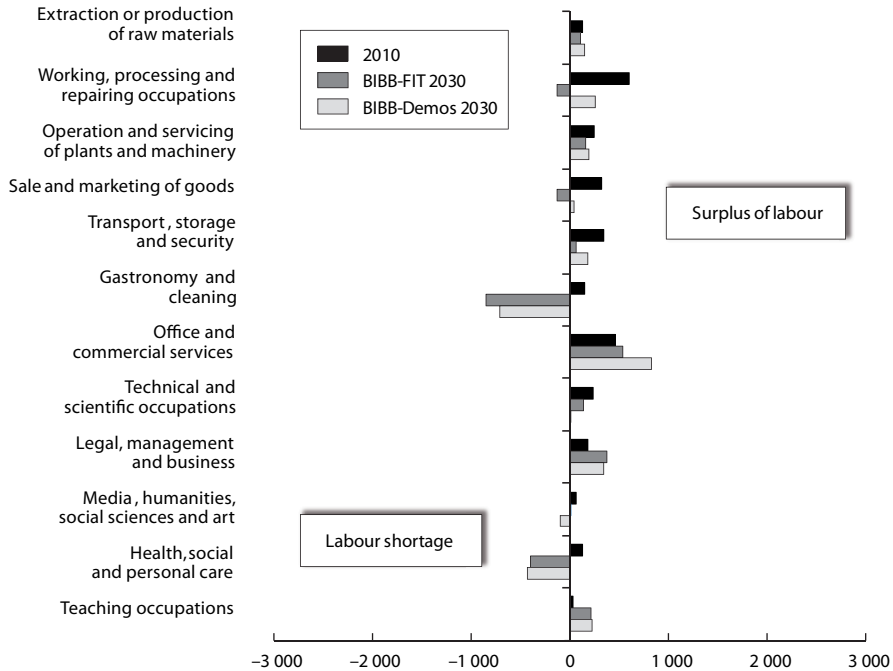
- Occupations involving the extraction or production of raw materials (MOF 1),
- Transport, storage and security occupations (MOF 5),
- Technical and scientific occupations (MOF 8),
- Teaching occupations (MOF 12).

An arithmetical workforce shortage arises in the major occupational fields for which the projections reveal the supply of workers to be inadequate in quantitative terms. These include:

- Working, processing and repairing occupations (MOF 2),

- Occupations involving the sale and marketing of goods (MOF 4),
- Hotel/restaurant and cleaning occupations (MOF 6),
- Occupations in the media sciences, humanities, social sciences or arts (MOF 10),
- Health, social and personal care occupations (MOF 11).

Figure 13 Difference between number of people in the economically active age and number of people in gainful employment by major occupational field, in 1 000s of people



Source: Helmrich et al. (2012)

It should be noted that these results assume the continuation of the status quo. Naturally, in reality this need not be the case. Gaps and overhangs in the workforce can be mitigated by companies' anticipatory and adaptive reactions on the demand side and by young people's changing IVET and occupational choices on the supply side, as well as possible political interventions. In addition, shortages may develop both regionally and within the major occupational fields presented here, yet not occur on the higher aggregate levels. Furthermore, we did not consider work-time volume in the calculations presented. If we consider that unskilled labour is not always employed in the desired amount of hours, we could possibly overcome labour shortages in the field of "Hotel/restaurant and cleaning occupations" (Zika et al., 2012).

CONCLUSION AND OUTLOOK

In our article, we first explained the need for an integral and simultaneous modelling approach as well as the need for a consistent data set and a high transparency and interdisciplinary. We think that the QuBe-modelling framework presented in this article reflects those expressed requirements. After explaining the assumptions that drive our model, we first focused on the demand side and thereafter on the supply side. Due to the consistent data set and the same taxonomy on the demand and supply side, we were able to contrast the future development of supply and demand in major occupational fields and qualification levels.

The results of our projections shows that Germany will expect skill shortages on the medium skill level and in "Working, processing and repairing occupations (MOF 2)", "Occupations involving the sale and marketing of goods (MOF 4)", "Hotel/restaurant and cleaning occupations (MOF 6)", "Occupations in the media sciences, humanities, social sciences or arts (MOF 10)" and "Health, social and personal care occupations (MOF 11)" if relationships that can be found in the past can also be extrapolated to the future. However, we are aware of the fact that labour-force shortages and surpluses in reality will not occur like the present.. A change in the responses of companies to market, educational and occupational choices of young people and also political interventions may mitigate labour shortages. Additionally, shortages may only be specific to particular occupations in certain regions or occur due to a mismatch of desired and actual hours worked.

What implications do our results have in practice? First of all, it should be clear that projections cannot picture the real future, but a consistent and possible future. Therefore, it is up to the researchers to provide a high transparency so that the reader can comprehend the assumptions behind the calculations. Furthermore, scenario calculations should be provided to give an idea about the different impact of the assumptions made. Furthermore, projections should continuously being updated to keep an eye on the sometimes marked changes in education and employment patterns at the current margin. Moreover, updates always give rise to new learning. The more frequently and regularly that systems are implemented, the greater the gain in knowledge. With this article we gave an overview on our leading assumptions and the greatest driver of our demand and supply forecast of qualifications and occupations. However, there are still two major points missing that have been addressed shortly in the paragraph above. One point is the interdependence of demand and supply and the other point is the regionalisation of the projection.

If the demand of an occupation increases faster than the potential supply of people with a qualification for this occupation, we should expect a wage increase in this occupation In consequence, we will have on the one hand a feedback on unit labour costs, prices, productivity and income, and therefore adaption processes within the enterprises to ensure productivity and on the other hand we could expect a reaction of occupational mobility behaviour and employment rates. However, this is only working in non-regulated labour markets. Labour markets with institutional restrictions, e.g. the health care sector, can probably not be solved through an increase in relative wage. In this case, other solutions are needed such as, for example, migration. This has to be considered when developing an interdependent demand-supply-model of the labour market.

The other aspect that cannot be addressed with a federal state model is that mismatches mainly happen on the regional level. This is why the regional level is becoming a major focus of attention. Important dimensions in this respect are demography, economic development by branches, and flexibility by occupational fields. Figure 2 could also be drawn for each of the German federal states. There are two further items to include: the consistency requirements on the supply side and, on the demand side, that people can move within Germany, but the sum of all net migration balances must be zero and the economic output calculated for the whole of Germany must be equal to the aggregated economic output of the individual federal states. One region's gains are always at another region's cost, unless the national result itself is amended. To model the regional demand, we will fall back on the LÄNDER model, a model in existence since 2001 that was developed within the framework of the IAB/GWS cooperation. In the LÄNDER model, developments in the sectors have been consistently linked with development at the national level. As well as sector-specific information, it also incorporates federal-state-specific information, so that data is already available on the development of demand for employees by location. Another existing model is PANTA-RHEI-Region, a model for every county district of Germany which has been used especially to ascertain different site uses (including industrial sites). On the supply side, population projections as well as the different mobility patterns of people with different formal qualifications are still to be discussed. Education is a competence devolved to the German federal states: differences within

the education and training system will have to be taken into account when creating a model. Some clear variations in employment patterns are also apparent by age and gender.

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Doctoral Students in Germany 2010: How Many Are There and What They Study

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Abstract

Data on doctoral students in Germany are required for national and international educational reports. However, due to the provisions in the enrolment and doctoral degree regulations at institutions of higher education, undercoverage of the data on doctoral students is observed in the statistics of students. Doctoral students who are not enrolled at institutions of higher education are not covered there. Hence, the Federal Statistical Office had been asked by the Federal Ministry of Education and Research to conduct a survey on doctoral students in Germany. The purpose was to develop a concept which provides reliable information on doctoral students in Germany. The survey provides comprehensive results on doctoral students in Germany in winter semester 2010/2011. It shows that about 200 400 doctoral students were supervised by professors at German institutions of higher education in winter semester 2010/2011.

Keywords

Doctoral students, institutions of higher education, professors, students, Federal Statistical Office of Germany

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I21

INTRODUCTION

The implementation of the consecutive study model as part of the Bologna process[3] elevates the doctoral phase to a new, separate level. Data on doctoral students is needed not only nationally, e.g. for the Fed-

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[3] In June 1999, the ministers of science from 29 European nations signed the Bologna Declaration (<*www.bologna-berlin2003.de/pdf/bologna_deu.pdf*>, accessed 19 June 2012) to create a uniform European higher-education zone. The primary objective of the reform process initiated in Bologna and at the follow-on conferences is to standardize the academic structures by introducing university degrees with different levels; see Willand, I.: "Bachelor und Master: Aktuelle Entwicklungen an deutschen Hochschulen" in WiSta 4/2005, pp. 372 ff.

eral Report on Promotion of Young Scientists ("Bundesbericht zur Förderung des wissenschaftlichen Nachwuchses"), but also for international education reporting.[4]

On account of the stipulations of the enrolment and doctoral programme regulations, the student statistics undercounts doctoral students. Doctoral students who are not enrolled at an institution of higher education are not counted here. As each institution of higher education, and sometimes even each faculty at such an institution, reports its doctoral students differently – due to different examination and doctoral regulations – it is currently impossible to determine the precise number of doctoral students in Germany on the basis of the student statistic. By contrast, the examination statistic of successful doctorates as well as the examination mark and the ages of the successful doctoral candidates is registered in great detail.

To this end, the German Federal Statistical Office conducted a survey of doctoral students in Germany on behalf of the Federal Ministry for Education and Research. The aim of this project was to develop a concept for providing reliable information on all doctoral students in Germany.

Article 7 (1) of the Federal Statistics Law formed the foundation for this survey.[5] In addition to the Federal Statistical Office, the statistical offices of the federal states of Baden-Württemberg, Bavaria, Berlin-Brandenburg, Hesse, Western Pomerania and North Rhine-Westphalia were involved in conducting the survey.

1 SURVEY CONCEPT

The survey was based on a two-stage procedure. At the first stage, 20 000 professors at German institutions of higher education with the right to award doctorates were asked in a voluntary survey to indicate the number of doctoral students supervised at the beginning of winter semester 2010/2011 as well as their type of doctoral studies and sex. Doctoral students covered were those guided by the professor as a (primary) supervisor. Another item covered was the professor's willingness to pass on the survey documents to their doctoral students at the second stage. This was crucial for the further process. The professors were either contacted directly or got the survey documents through an internal distribution procedure applied at the respective institution of higher education. In a second stage, a survey was conducted among 20 000 doctoral students. At this second survey stage, the professors were asked to pass on the survey documents to their doctoral students. The doctoral students were questioned on sociodemographic variables, on when they started their doctoral studies, on their employment status and on any financial aid programmes.

2 SAMPLING CONCEPT

As for the survey concept a two-stage procedure was applied in the sampling concept. The information obtained in the survey of professors at the first stage was needed for sampling in the survey of doctoral

[4] In the European Union (EU), Regulation (EG) No. 452/2008 of the European Parliament and the Council dated 23 April 2008 on the preparation and development of statistics on education and life-long learning (Official Journal of the EU No. L 145, page 227) sets out the obligation to provide statistics on the systems of general and vocational education. Regulation (EU) No. 88/2011 of the Commission dated 2 February 2011 (Official Journal of the EU No. L 29 dated 3 February 2011, page 5) on execution of Regulation (EG) No. 452/2008 stipulated that members states had to provide information on their doctoral students in September 2012. In a decision of the Commission taken in December 2010, however, exceptions were granted to the implementation of the Regulation (resolution 2010/786/EU of the Commission dated 17 December 2010, Official Journal of the EU No. L 335 dated 18 December 2010, page 66). In one such exception, Germany was permitted to provide data on doctoral students one year later, in 2013.

[5] "Gesetz über die Statistik für Bundeszwecke (Bundesstatistikgesetz – BStatG)" dated 22 January 1987 (BGBl. I page 462, 565), most recently amended by Art. 3 of the Law dated 7 September 2007 (BGBl. I page 2246). Art. 7 (1) BStatG: "In order to fulfil a data requirement arising on short notice for the purposes of preparing and justifying upcoming decisions of top-level federal agencies, federal statistics with no obligation to disclosure may be conducted when a top-level federal agency requires such a federal statistic." An article 7 survey may not question more than 20 000 respondents, and the respondents' participation is voluntary.

students (stage 2). At the first stage, 20 000 professors at German institutions of higher education with the right to award doctorates were sampled. For this purpose, a cluster sample was used with the institutions of higher education as clusters. For the participating institutions of higher education, a Bernoulli sampling procedure with an inclusion of probability proportionate to "doctorates per chair and year" was used. To avoid large design weights, the minimum inclusion probability was set to 1/10. However, large institutions of higher education were sampled with a probability of 1 to avoid excessive variations in the number of professors interviewed. A total of about 19 500 professors were actually interviewed at the first survey stage. In the sampling concept for the survey of professors, it was defined that not all institutions of higher education in Germany with a right to award doctorates had to be included in the survey. At the second stage, 20 000 doctoral students were sampled. These students were of those professors who had agreed to pass on the survey documents to their doctoral students at the first stage. Thus, the results of the first stage of the survey among professors were the sampling basis for the second stage, the survey among doctoral students. The professors who had agreed to participate in the second stage were stratified by federal state, institution of higher education, as well as teaching and research area or subject of the doctoral advisor. The sample size was distributed proportionately to the strata; when selecting the professors, care was taken that small groups, such as doctoral students with an external type of doctorate, were sufficiently represented in the sample. The total of 19 998 doctoral students was sampled at random from the sampling frame with the condition that all doctoral students of a specific professor are selected.

3 EXTRAPOLATION METHOD

In line with the study concept, the results of the two surveys were extrapolated in two stages, too. The general goal of extrapolation was to take the sample parameters (total value, mean value, proportion, variance) as a basis for making conclusions for the parameters of the population, using suitable estimators. An unbiased estimate of the unknown total value of a relevant variable Y is obtained through a generalised regression estimator (GREG). The regression estimator is a linear estimator and one of its characteristics is that the benchmarks are met during extrapolation from the sample. This methodological approach was applied for extrapolation in the surveys. Furthermore, the regression approach has the advantage that the approximate formula of the variance of the estimator has a closed representation. In turn, the variance can be estimated from the sample. Consequently, the estimation error can be quantified for any target group after every extrapolation. The relative standard error can be indicated as a measure of the random error. The standard error is calculated by means of the CLAN SAS macro of Statistics Sweden.

In the first stage of the survey, about 9 400 (48%) professors had responded and were available for extrapolation. About 6 800 of them were willing to pass on the questionnaires to their doctoral students. The basis for the first extrapolation stage was benchmarks from the statistics on higher education personnel. Referring to 2010, those figures covered all 33 800 professors at German institutions of higher education with a right to award doctorates. From them, benchmarks for the professors were derived regarding the areas of study or subject groups, main or secondary occupation, sex, distribution by former territory of the Federal Republic as well as Former East Germany and Berlin-East, and the common distributions between areas of study and the professor's activity.

In the second stage of the survey, about 8 700 (43%) doctoral students had responded to the survey referring to 1 800 professors out of the 6 800 who were willing to pass on the questionnaires to their doctoral students. The basis for the second extrapolation stage was benchmarks of the enrolled doctoral students, taken from statistics of higher education for winter semester 2010/2011. To ensure that both extrapolations refer to the same number of doctoral students, the number of doctoral students calculated in the first stage was taken as an additional benchmark in the second extrapolation. A strong correlation was found between the number of a professor's doctoral students and the probability that at least one of them participated in the survey. During extrapolation, this correlation was taken into account by

weighting. The surveys on doctoral students in Germany thus provide results both at the level of professors and at the level of doctoral students.

4 RESULTS

The surveys on doctoral students in Germany provide comprehensive information on doctoral students in Germany in winter semester 2010/2011. They show that in winter semester 2010/2011, the approx. 33 800 professors at German institutions of higher education with the right to award doctorates supervised almost 200 400 doctoral candidates.

In all, around 2.2 million persons studied at German institutions of higher education in winter semester 2010/2011. According to the results of the official statistics of higher education, this figure included around 104 000 doctoral students enrolled at the institutions of higher education and seeking a doctorate. This means that almost the same number of persons who were not enrolled at an institution of higher education was working on a doctorate under the supervision of professors.

According to the results of the official statistics of higher education 25 600 persons successfully earned their doctorate in 2010.

4.1 Doctoral students by selected areas of study

Around 58 400 doctoral students were seeking a doctorate in the area of study Mathematics and Natural Sciences; that was 29% of all doctoral students in winter semester 2010/2011. With 44 500 doctoral students (22%), Engineering was the area of study with the second-largest proportion of all doctoral students. 38 700 doctoral students (19%) were supervised in the subject group Languages and Cultural Studies, followed by Law, Economics and Social Sciences with 35 900 doctoral students (18%). In the area of Human Medicine and Health Sciences, 8 300 persons (4%) were seeking a doctorate.

A comparison of the proportions of doctoral students by areas of study with those with a completed doctorate shows that these proportions clearly deviate. Students' tendency to pursue a doctorate varied depending on the area of study. The employment situation in higher education, the availability of research funding and doctoral scholarships, the importance of the doctorate for the desired career track and personal reasons all have an effect on the willingness of university graduates to pursue a doctorate.

Whereas students in the area of study Law, Economics and Social Sciences made up 31% of all students, the proportion of this area of study in enrolled doctoral students was 19% and all doctoral students of the surveys 18%. In turn, only 14% of awarded doctorates went to the area of study Law, Economics and Social Sciences. The situation was the reverse for the area of study Mathematics and Natural Sciences: in winter semester 2010/2011, 18% of students belonged to this area of study. The proportions of enrolled doctoral students and all doctoral students contained in the surveys were substantially higher, at 34% and 29% respectively. A doctorate appears advantageous for pursuing a career in this area. In the area of Mathematics and Natural Sciences, there are research topics for which funding is also available. With 32%, the proportion of completed doctorates in Mathematics and Natural Sciences was the highest of all areas of study (see Table 1).

The area of Medicine represents a special case. The proportion of students in the area of study Human Medicine and Health Sciences out of all students in winter semester 2010/2011 was 6%. For the enrolled doctoral students and all doctoral students of the surveys as well, only low proportions of 6% and 4%, respectively, were achieved. By contrast, 28% of all doctorates in 2010 were completed in this area. The reasons for the large differences could be that a doctorate is standard in medicine, and doctoral students in medicine pursue their doctorates concurrently with their regular studies and thus complete it in a shorter period, or while working as assistant physicians or learning a specialty.

Table 1 Proportion of doctoral students, enrolled doctoral students, the Doctor`s degree examniations and students in the official statistics of higher education by areas of study in winter semester 2010/2011* (in%)

Areas of study	Survey on doctoral students	Official statistics of higher education		
	Doctoral students	Enrolled doctoral students	Doctor´s degree examination	Students
Languages and Cultural Studies	19	23	11	19
Law, Economics and Social Sciences	18	19	14	31
Mathematics/Natural Sciences	29	34	32	18
Human Medicine	4	6	28	6
Other subjects	29	17	15	27
Total	**100**	**100**	**100**	**100**

* Variations of 100% conditioned by roundings.

Source: Federal Statistical Office of Germany, Promovierende in Deutschland 2010; Fachserie 11, Reihe 4.1, Wintersemester 2010/2011; Fachserie 11, Reihe 4.2, PJ 2010

When comparing the various statistics, it must additionally be considered that no information is available on withdrawals and length of doctoral studies in the respective areas of study. A large proportion of the doctoral students and a low proportion of completed doctorates could indicate a long doctoral duration or a high withdrawal ratio.

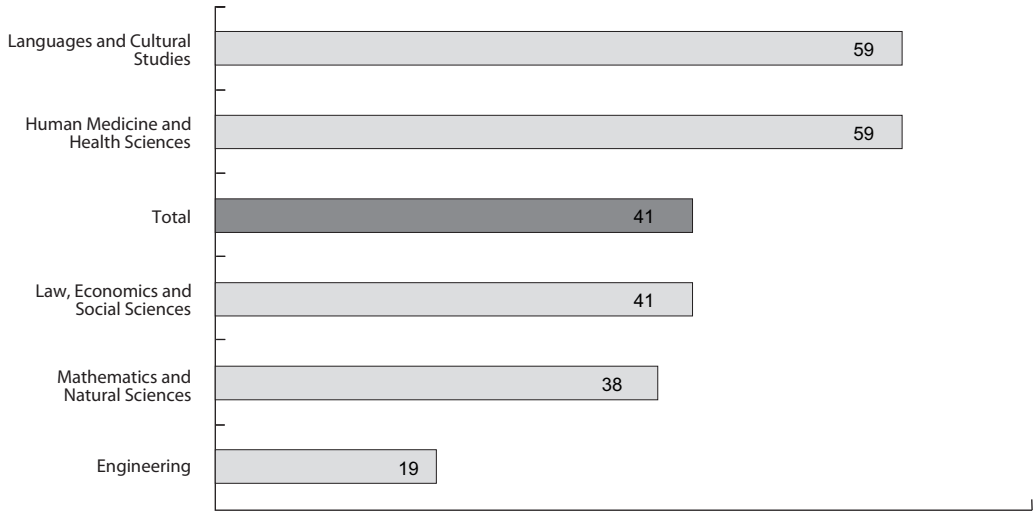
4.2 Doctoral students by gender

41% of all doctoral students in Germany were women in winter semester 2010/2011. Compared to all students (proportion of women: 48%) and enrolled doctoral students contained in the official statistics of higher education (proportion of women: 45%), the proportion of women among all doctoral students was thus somewhat lower. The proportion of women among completed doctorates was 44% in 2010. The gender distribution of all doctoral students by areas of study varied markedly. As for students overall and enrolled doctoral students contained in the official statistics of higher education, and for all doctoral students there were areas of study in which men were overrepresented, and those preferred by women. In the areas of study Languages and Cultural Studies and Human Medicine and Health Sciences, women doctoral students were overrepresented, with 59% in each group. In the area of study Law, Economics and Social Sciences, the proportion of women, at 41%, corresponded exactly to the average of all areas of study. In the areas of study Mathematics and Natural Sciences (proportion of women: 38%) and Engineering (proportion of women: 19%), by contrast, women doctoral students were significantly underrepresented (see Figure 1).

4.3 Doctoral students by age

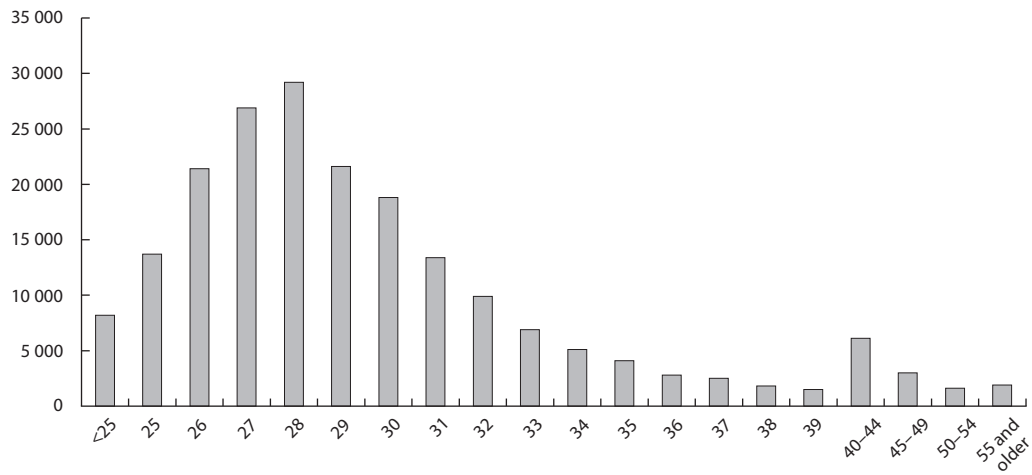
Of the doctoral students supervised at German institutions of higher education in winter semester 2010/2011, the biggest group was 28 years old (29 200 doctoral students or 15%). 27-year-olds made up the second-largest group with 26 900 doctoral students (13%). This was followed by the age groups of 29-year-olds with 21 600 doctoral students and 26-year-olds with 21 400 doctoral students, or 11% each. 18 800 (9%) doctoral students were 30 years old. Thus, in winter semester 2010/2011 around 59% of doctoral students were aged 26 to 30. 11% of doctoral students were 25 and younger. 60 600 doctoral students (30%) were 31 and older. The number of doctoral students declines rapidly with increasing age (see Figure 2).

Figure 1 Proportion of women by selected areas of study in winter semester 2010/2011



Source: Federal Statistical Office of Germany, Promovierende in Deutschland 2010

Figure 2 : Doctoral students by age in winter semester 2010/2011



Source: Federal Statistical Office of Germany, Promovierende in Deutschland 2010

A comparison of the age distribution of women and men seeking doctorates reveals that the proportion of doctoral students 25 and younger was slightly higher among women at 14%, as compared to men with 9%. On the other hand, the proportion of women in the age groups 31 and older was lower than for men. Of female doctoral students, 28% were 31 or older, as compared to 32% for male graduate students.

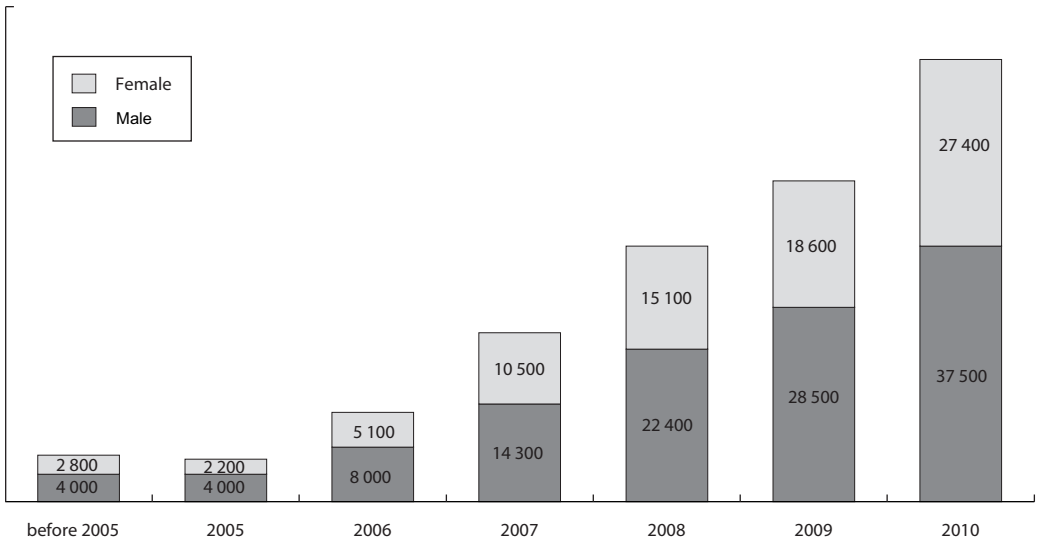
The gender distribution in the individual age groups largely approaches the gender distribution for all doctoral students. The proportion of women was greatest in the age group 25 and younger, in which women made up 51% forming a slight majority. One likely reason for this is that men usually attain their first degree later then women, e.g. on account of military or civilian service which was compulsory for

men in Germany until June 2011. In the examination year 2010, 55% of women who successfully attained their first degree were 25 years of age or younger, as compared to 41% of men. In the age groups of 29-, 30- and 34-year-old doctoral students, women were underrepresented, at 36% each. At 35%, the proportion of women was lowest among 31-year-olds.

4.4 Doctoral students by commencement of doctoral studies

One third of the 200 400 doctoral students commenced their doctoral studies over the course of 2010. 47 100 doctoral students, or 24%, began their doctorates in 2009, and a further 37 500 persons (19%) began in 2008. 24 800 doctoral students had been working on their doctorate since 2007; that is equivalent to 12% of all doctoral students in winter semester 2010/2011. Around 13 100 persons (7%) had been pursuing their doctorates since 2006, and a further almost 6 200 persons (3%) since 2005. 6 800 doctoral students (3%) had their doctorates before 2005 (see Figure 3).

Figure 3 Doctoral students by commencement of doctoral studies in winter semester 2010/2011



Source: Federal Statistical Office of Germany, Promovierende in Deutschland 2010

4.5 Doctoral students by employment situation

In winter semester 2010/2011, 165 600 of the 200 400 doctoral students were employed (83% of all doctoral students). Of those doctoral students employed, 126 000 or 76% were employed at an institution of higher education. 12 400 doctoral students (8%) were employed at a non-university research institute. Slightly less than 16% of doctoral students found employment in private enterprise or with other employers.

4.6 Doctoral students by financial aid programmes

In all, around 52 300 doctoral students received public financial aid in winter semester 2010/2011; that was 26% of all doctoral students. 57% of persons receiving financial aid were men while 43% were women. The largest group of doctoral students receiving financial aid (around 20 500 persons or 39% of all those receiving financial aid) was supported by the German Research Foundation DFG. 7 500 doctoral students (14%) received aid from a Ministry of Economics of a federal state and 4 800 (9%) from an or-

ganisation supporting intellectual excellence (Begabtenförderwerk). This category comprises a variety of foundations. The German Academic Exchange Service DAAD assisted around 2 700 doctoral students (5%; see Table 2).

Table 2 Doctoral students by financial aid programmes in winter semester 2010/2011

Financial aid programmes	Doctoral students		
	Total	Male	Female
Total	**52 300**	**29 700**	**22 600**
of which:			
German Research Foundation (DFG)	20 500	12 600	7 900
Ministry of Economics of a Federal State	7 500	4 200	3 300
Begabtenförderwerk	4 800	2 400	2 400
German Academic Exchange Service (DAAD)	2 700	1 700	1 000

Source: Federal Statistical Office of Germany, Promovierende in Deutschland 2010

The doctoral students supported by a financial aid programme were distributed differently over the areas of study. With 20 800 persons or 40%, the largest group of doctoral students receiving financial aid belonged to the area of study Mathematics and Natural Sciences. 20% of doctoral students in the area of study Languages and Cultural Studies (10 500 recipients) and Engineering (10 200 recipients) benefited from financial aid programmes. Furthermore, 11% (6 000 persons) of supported doctoral students belonged to the area of study Law, Economics and Social Studies.

Out of the total of 200 400 doctoral students, 83% were employed; of the 148 100 doctoral students not receiving financial aid, this proportion was somewhat higher, at 89%. Almost two-thirds of the 52 300 doctoral students receiving public financial assistance were working in winter semester 2010/2011: eight out of ten doctoral students supported by the German Research Foundation were employed. This proportion was close to seven out of ten for those doctoral students receiving financial aid from a Ministry of Economics of a federal state. Of those doctoral students receiving scholarships from an organisation supporting intellectual excellence, only four out of ten were employed. However, it has to be kept in mind that scholarships are often only granted when the recipient doctoral students do not have any financial resources above a certain amount. Potential income is offset against the scholarship.

Further detailed results are described in the report „Promovierende in Deutschland 2010“ (publication in German language) which can be found on the website of the German Statistical Office (*www.destatis.de*) under “Publikationen > Thematische Veröffentlichungen > Bildung, Forschung, Kultur > Hochschulen”.

CONCLUSION AND OUTLOOK

Our analysis show comprehensive results on doctoral students in Germany in winter semester 2010/2011. It shows that in winter semester 2010/2011, professors at German institutions of higher education supervised 200 400 doctoral candidates. Almost as many persons as the 104 000 doctoral students enrolled at institutions of higher education in Germany, were pursuing their doctorates without being enrolled at an institution of higher education. Most doctoral students were seeking a doctorate in the areas of Mathematics and Natural Sciences (approx. 58 400 doctoral students or 29% of all doctoral students), followed by Engineering with 44 500 doctoral students (22%).

41% of all doctoral students in Germany were women in winter semester 2010/2011. The largest agegroup of doctoral students was 28 years in winter semester 2010/2011.

About 64 900 doctoral students (32%) started their doctoral studies in 2010. About 47 100 doctoral students (24%) started in 2009 and 37 500 (19%) in 2008. In the years from 2005 to 2007, the number of

doctoral students taking up their doctoral studies was 44 100 (22%), while 6 800 doctoral students (3%) had started before 2005.

The need for data on doctoral students remains, both nationally and internationally. The results relating to doctoral students in Germany obtained through the Sec. 7 surveys provide up-to-date information on this group of persons. In the coming months, a method is to be developed for updating the results obtained on doctoral students. In order to verify the updated results and improve the calculation of updating a basis for comparison is required. For this reason, a repetition of the article 7 surveys is considered appropriate. In its position paper "Anforderungen an die Qualitätssicherung der Promotion (Requirements for quality assurance in the doctoral sector)",[6] the German Council of Science and Humanities (Wissenschaftsrat) recommended that the institution of higher education reports the number of doctoral students in Germany according to a uniform principle. The aim is to obtain reliable data on the doctoral students and thus also enable the observation of the doctoral process. The Council of Science and Humanities recommends granting each doctoral student "a uniform doctoral status independent of the nature of financing",[7] which the doctoral students receive in the form of an official acceptance at the institution of higher education. If this proposal were broadly implemented, and if all institutions of higher education counted their doctoral students completely at one central location, in future the possibility would exist of reporting information on the doctoral students in official statistics. The information about doctoral students could be integrated in the ongoing delivery plan of the institutions of higher education and thus permanently obtain reliable information about the doctoral students. However, this would require an amendment of the law of official statistics of higher education.

Having reliable numbers of doctoral students in Germany reported on a regular basis is desirable. Additionally it would improve comparisons between European countries.

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[6] German Council of Science and Humanities (Wissenschaftsrat): "Anforderungen an die Qualitätssicherung der Promotion – Positionspapier des Wissenschaftsrates", Halle 2011, page 37.

[7] Footnote 6, here: page 17.

Geostatistics Portal – an Integrated System for the Dissemination of Geo-Statistical Data

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Abstract

A wide range of applicability of spatial statistical data for managing and planning various human activities in the environment or monitoring the trends of different phenomena in space and time requires an adequate response from data providers. The Statistical Office of the Republic of Slovenia (SURS) has a long tradition of processing geo-referenced statistical data that can be point located or aggregated to an optional (administrative) spatial unit and in line with the increasing need for geo-referenced statistical data of high resolution, SURS followed the users' needs by developing various services that are a part of an integrated system for the dissemination of geo-statistical data.

The article discusses the production of geo-statistical data in Slovenia with the focus on the grid data, related confidentiality issues and the system for the dissemination of geo-statistical data, i.e. the Geostatistics portal.

Keywords

Grid data, statistical confidentiality, data visualisation

JEL code

Z, C

INTRODUCTION

Geographical information systems (GIS) have opened a new dimension in understanding of the dissemination of spatial statistical data. To meet the requirements of the growing community of spatial data users, the Statistical Office of the Republic of Slovenia (SURS) adopted new means and formats of spatial data dissemination where grid data proved to be the most challenging. Introducing grids to the standard dissemination process demands a redefinition of the data disclosure rules since grids usually present the phenomena in high spatial resolution. Secondly, the size of the grid data files and the high number of grid cells bearing the data values requires innovative solutions regarding the cartographic presentation and download of the data on the internet.

The entire process of establishing the integrated system for the dissemination of geo-statistical data was primarily focused on creating grid data and the development of the web mapping application that would enable the grid data presentation but parallel to that all data from various statistical domains were

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examined regarding their potential to be included into this system. This cross-examination considered how detailed the particular variable or a set of variables could be presented regarding their reliability and confidentiality. The aim is to present all the data available with the highest spatial resolution possible.

1 GEO-REFERENCING

1.1 Historical background

Register-oriented statistics in Slovenia as expected offered a good foundation for creating geo-statistical data of high resolution. The Register of Spatial Units – initiated by SURS and now managed by the Surveying and Mapping Authority of the Republic of Slovenia – was the first step towards a sound territorial division which enabled geo-referencing (point locating) of statistical data (1971 Population and Housing Census) in Slovenia. These 1971 Census data were used for the establishment of the Central Population Register (CPR) and for the very first time personal identification numbers were assigned to the people residing in Slovenia (Oblak Flander, 2007), which is important for easier later joining of the data from some registers. Although these data could be stored only in tables and not really managed graphically as they can be today by means of GIS, it was decided to permanently preserve the spatial references of the highest possible (or acceptable) positional accuracy.

This far-sighted decision became very relevant when the graphical part of the Register of Spatial Units was completed in 1995. The data stored in tables did have their spatial reference but before that it was very difficult or even impossible to analyse them by means of GIS on the entire national territory. Practically this means that from 1995 on e.g. population data captured in the 1971 Census could be graphically presented for each person on a map at least to the enumeration area (later transformed into spatial districts) of their permanent residence if not down to an address. When SURS started to handle spatial statistical data on grids, mostly the point located data from various registers were considered as applicable, but later also some methods were tested on how to improve the positional accuracy of polygon data while point locating them and aggregating them to grids as described further on. Statistical data from the 1971, 1981, 1991 and 2002 censuses together with the data from the CPR thus offer an important historical picture on how various spatial phenomena changed over the last forty years.

1.2 National hierarchical grid system

SURS has been involved in handling of spatial statistical data on grids since early 1990s with first results of these spatial statistical analyses presented at the end of the decade (Figure 1).

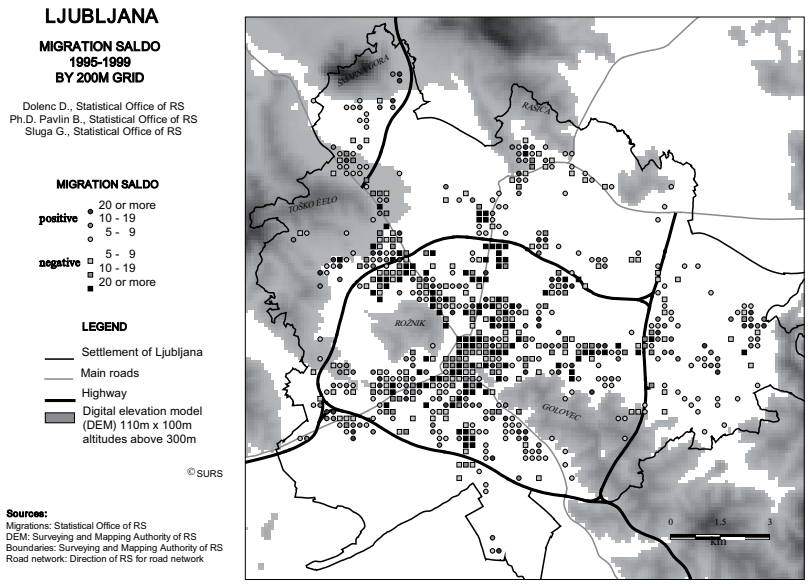
Since then there has been an increase in user demands for statistical data in GIS format, which convinced SURS to further explore the advantages of handling statistical data on grids together with dissemination of such data. Lessons learned from individual case studies and disseminations were obviously to result in the intention to establish a national hierarchical grid system in 2008. Three institutions agreed to cooperate: SURS provided methodological support and the Geodetic Institute of Slovenia together with the Surveying and Mapping Authority of the Republic of Slovenia provided technical support.

The purpose of the joint project was to:

- create square grid vector layers with seven different basic sizes of grid cells,
- define the grid cell nomenclature accordant with the hierarchical structure of grid cells,
- define the origo of the hierarchical grid system,
- define the grid cells both in the previous (D48/GK) and the present (D96/TM) national coordinate systems.

The seven basic grids are 100 m, 200 m, 500 m, 1 000 m, 2 500 m, 5 000 m and 10 000 m grid. The smallest grid cell size 100 m × 100 m was defined considering the user needs for spatial statistical data of high resolution, compliance with other spatial databases in Slovenia and the fact that SURS decided not to present the data for grids smaller than 1ha.

Figure 1 Ljubljana migration balance 1995–1999 on 200m grid



Source: Statistical Office of the Republic of Slovenia

To solve the problem of converting the data from one coordinate system to another it was decided to define square grid vector layers first in D96/TM and then to transform them into D48/GK where grid cells from both coordinate systems share the same cell ID. Transformed grid cells in old coordinate system D48/GK insignificantly lose their square shape but the same cell still covers the same area. Therefore all official spatial statistical data or user's own spatial data which are mostly still in previous D48/GK coordinate system can simply be aggregated to grids in D48/GK and then transformed to D96/TM using the cell IDs. This solution eliminates the problem with overlapping two e.g. same 100m grid datasets defined in different coordinate system (different origo) which might reveal the data values for area smaller than 1 ha.

1.3 Polygons to grids

After establishing the graphical part of the Register of the Spatial Units in 1995 practically all statistical data could be linked to their coordinates and consequently aggregated to optional spatial units including grids. Although the data prior to that could be point located as well by means of various cross-identifiers in reality the greater the time distance the less e.g. persons can be located to coordinates of their permanent addresses. Therefore, some alternative solutions were sought and since the majority of the historical data could still be geo-referenced at least to nowadays spatial districts (originated from enumeration areas) and the fact that the spatial districts are rather small in size their centroids (Figure 2: blue dots) were used as reference coordinates for the aggregation of these data into grids. The centroids of spatial districts are suitable as they are not merely a geometrical centre of the polygon but they mostly coincide with the area of the highest population density in that particular spatial district. These centroids are namely defined by the location of significant objects, e.g. schools. Such centroids can be aggregated to grids as point located data are nowadays, only that the data value for the entire spatial district is geo-referenced to that one coordinate of the centroid of the spatial district. Spatial districts without significant objects obtain their centroids from other significant objects, i.e.:

– centre of gravity of densely built-up area of the spatial district,
– centre of gravity of all buildings in the spatial district when buildings are scattered,
– centre of gravity of the spatial district when there are no buildings in the spatial district.

Any territorial change of the spatial district consequently means a change of its centroid. Despite this, the centroids of spatial districts were additionally examined and corrected where necessary since the population distribution has changed over the past decades significantly in some areas. The correction performed was based on the present state of the centroids of buildings where the information of the construction year of buildings was used to select only buildings which existed and were populated in a particular census period. A common centroid of populated buildings for an individual spatial district is calculated as the average X and Y coordinate of the centroids of populated buildings. Thus a weighted gravity point location of population distribution per spatial district (Figure 2: triangles) is acquired and can be applied to the bottom-up aggregation method (Figure 2).

Figure 2 Aggregation of spatial districts by means of their centroids (circles) or centroids of populated buildings (triangles) into 1 km × 1 km grid

Source: Own construction

In other situations where for instance the number of working places is presented, the centroid of the spatial district can be corrected according to the centre of gravity of all buildings with business activity. Additionally, the position accuracy of 1981 and 1991 census data on population when aggregated to grids can secondly be examined with geo-referenced data from the Central Population Register already available for those periods.

Different from point located data, the polygon data determine the grid cell size according to their average area. Spatial districts in densely populated urban areas cover smaller areas and in rarely populated areas larger areas. Several spatial analyses indicated that the census data can be aggregated to grids with

the cell size 100 m × 100 m or 200 m × 200 m for high, 500 m × 500 m for medium and 1 km × 1 km for low population density areas. Table 1 compares the area of spatial districts to area of 100 m, 200 m, 500 m and 1 km grids together with the number of population. Approximately 47% of the population can be directly aggregated to 100 m, 200 m or 500 m grids thus ensuring high resolution spatial data in densely populated areas.

Table 1 Comparison between spatial districts and grids regarding the area and population distribution

Area of spatial districts in km^2	% of all spatial districts	% of total population	% of national territory	Population / km^2
area ≤ 0.01	11.80	10.85	0.05	20 078
0.01 < area ≤ 0.04	14.28	15.70	0.27	5 770
0.04 < area ≤ 0.25	19.40	20.85	1.90	1 095
0.25 < area ≤ 1	22.15	20.14	11.18	179
area > 1	32.36	32.46	86.60	37

Source: Own construction

The applied methodology suggests that it is highly recommendable to store the census (or other) data together with spatial references of the highest possible positional accuracy if that is legally and technically possible. Positional accuracy can be improved when relevant spatial objects (e.g. buildings) to which most of the data are related are assigned to co-ordinates of their point location and this only has to be done once. A great advantage of geocoded data transformed in this way is that they can be aggregated to an optional grid system regardless of its cartographic projection or coordinate system, but, of course, still considering the appropriate grid cell sizes. Additionally, these data also acquire all advantages of the grid data mentioned above.

2 STATISTICAL CONFIDENTIALITY IN SMALL AREA STATISTICS

Dissemination of geo-referenced statistical data is sensitive since the location of the data is information that could potentially lead to disclosure of the unit of observation, particularly when dealing with data high resolution, e.g. enumeration areas or small grid cells. To assure the confidentiality of the data, SURS defined a set of confidentiality rules that consider sensitivity of variables. Procedures for managing confidentiality are typically produced with coordination of subject-matter specialists, regional statistics specialists and statistical disclosure control experts.

The confidentiality rules differentiate between statistical data geo-referenced to administrative units and grid data. Grid data namely consider the sensitivity of the data and the area of the grid cell size, which should not be smaller than 100 m × 100 m square (1 hectare). Statistical data geo-referenced to administrative units are on the other hand presented regardless of the area of individual administrative unit only considering the sensitivity of the data. Data suppression is used to protect sensitive cells in the attribute table of geo-referenced data sets.

Discussing many solutions already tested and implemented by other NSIs (Strand, Holst Bloch, 2009), it was decided to define the disclosure rules according to the user needs. The analysis of the user requests for geo-statistical data in previous years as expected showed that in case of demographic statistics the users require more spatially and attributively detailed statistical information for densely populated areas where basic figures coming in high resolution were sufficient for remote areas. This fact resulted in determining the non-sensitive statistical data that can be presented without suppression also at the level of settlements and 100 m × 100 m grid cells. These are mainly absolute figures but also sex and age population structure. On the other hand, the sensitive data were determined which are disclosed when the necessary threshold is reached and offer more detailed structure of the attributes. The advanced

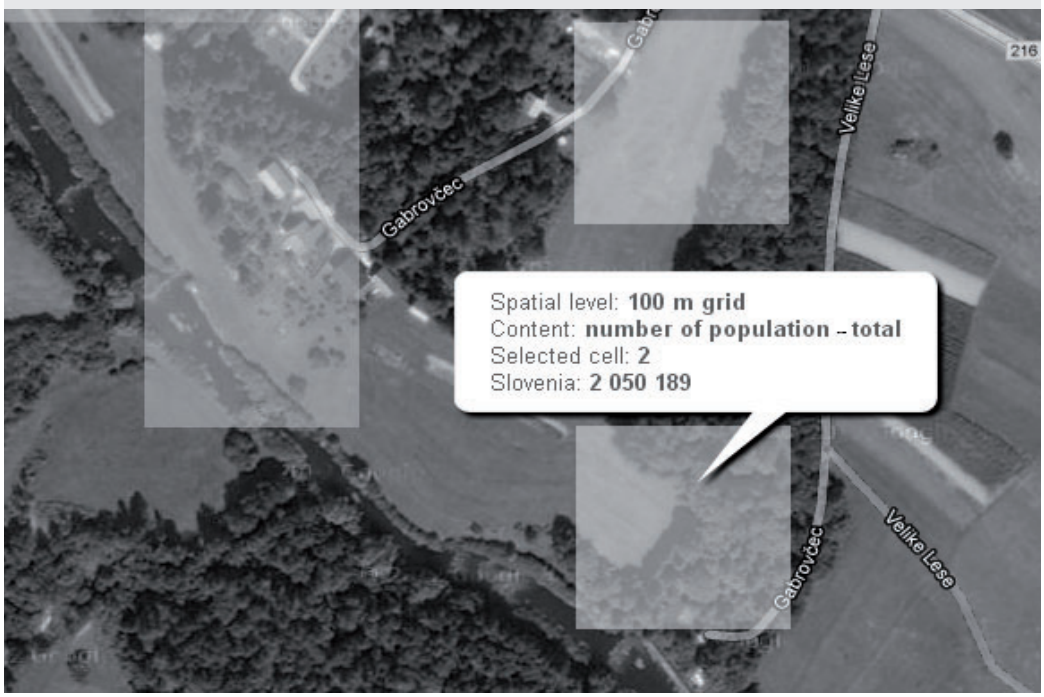
users have as they did in the past still the option to aggregate the spatial units according to their needs, so that the thresholds are met and more information is disclosed for areas where particular phenomena occur in lower density.

The current set of variables available also on 100 m × 100 m grid cells:

- Population:
  - number, sex, age groups,
  - population ≥ 30 → education, activity.
- Households:
  - number,
  - population ≥ 30 → household size.
- Dwellings:
  - number,
  - population ≥ 30 → dwelling area in classes.
- Buildings:
  - number,
  - buildings ≥ 30 → building age in classes.

This method of statistical disclosure was also recognised as optimal since all geo-statistical data are or will be included in various web mapping applications. When combining these data with other geographical information – e.g. satellite images from Google maps – the data may become directly related to individual houses (in case of population data) rather than just the spatial units they are aggregated to (Figure 3).

Figure 3 Web mapping application KASPeR – Potentially problematic presentations of the geostatistics revealing the exact locations



Source: KASPeR, own construction

3 DISSEMINATION SERVICES

The integrated system for the dissemination of geo-statistical data joins various services within the developing Geostatistics portal which will become a common entrance to these types of data and information. The basis of this system is an application for cartographic presentation of the data and download called KASPeR.

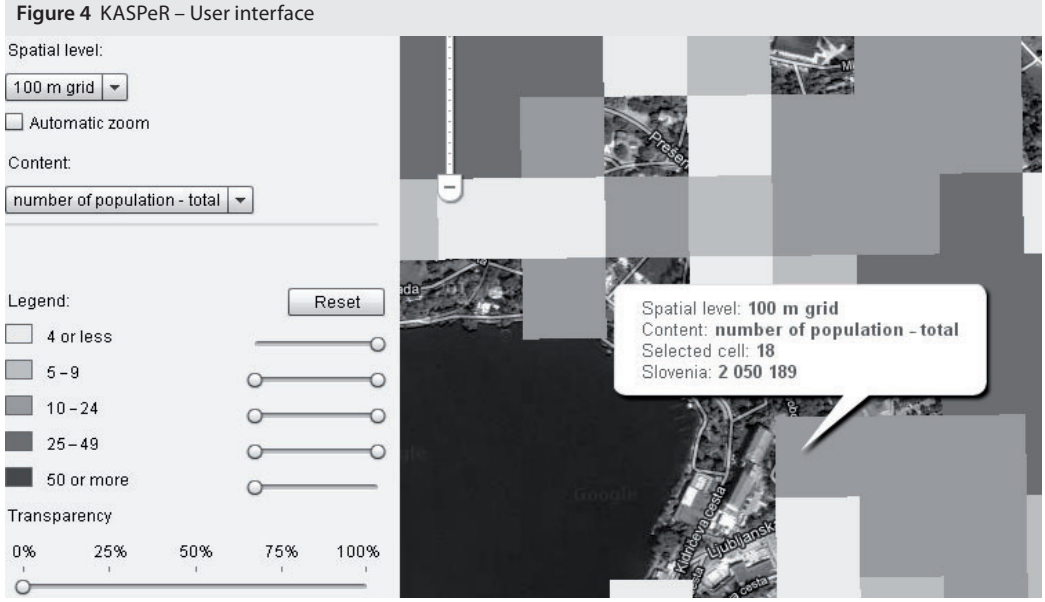
3.1 Visualisation tools

First interactive cartographic presentations of statistical data on the official website were maps created with the PX_MAP, which is a map module within the PC-Axis software family and enables the users to display the selected data in a symbol or a choropleth map. Interactive Statistical Atlas that followed is a Flash based application that allows more interactivity but remains focused on administrative units (NUTS 3, LAU 2). Very popular with the users is a simple application "Place names" presenting the location of the settlements considering the grammatical characteristics of their names. Besides the interactive applications, SURS also offers thematic maps from various statistical domains.

3.2 KASPeR

Web mapping application KASPeR enables visualization of statistical data on different administrative units or grids in combination with maps from the Google Maps tool. The application was designed and developed in cooperation with the Geodetic Institute of Slovenia to explore the possibility of including geo-referenced statistical data of high resolution in a mapping application that would bring the statistics of the 2011 population census to a living environment of an individual. Downscaling from the country level through administrative units to a 100m grid in real time with the help of transparency slider successfully meets that purpose. The application offers a set of demographic variables that can be presented and downloaded as a thematic map. Furthermore, the advanced users are offered a download service that provides free access to geo-referenced statistical data in vector format (*.shp). These data are a valuable input for spatial analyses and data presentation.

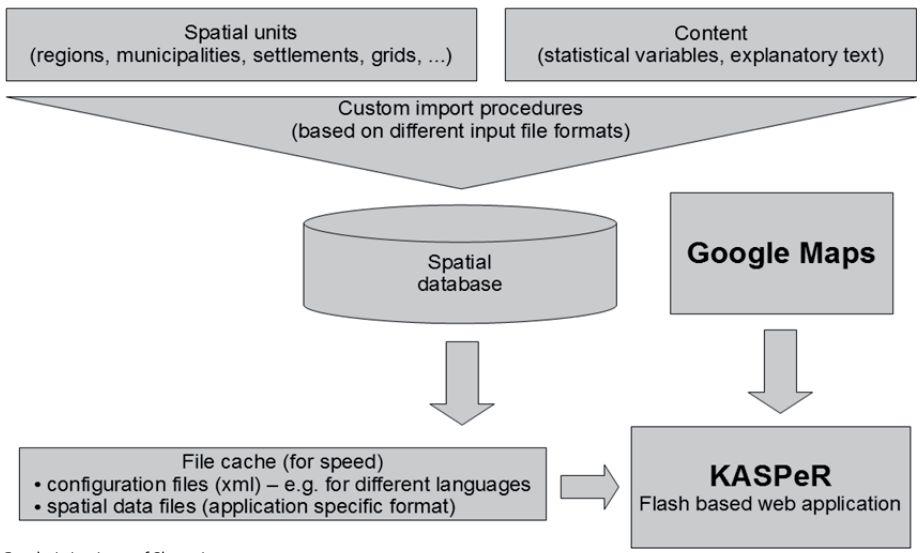
Figure 4 KASPeR – User interface



Source: KASPeR, own construction

The application has a simple data infrastructure with a virtual database supporting the graphical presentations in KASPeR. Spatial units in the form of SHP files are rasterized and organized in a pyramidal hierarchy. Data values are extracted from SHP files and uploaded to a server in compressed data format optimized for quick performance. Administrative units are retrieved from the Register of Spatial Units and assigned the data from the statistical database. Grid data on the other hand are aggregations of point located data with coordinate of the centroid of buildings with an address as a point reference. Since KASPeR is considered more as an experiment, no complex data infrastructure was developed. Consequently, a lot of manual work is involved in the data support, so it soon became obvious that any further improvements of the application should consider automating data input and update.

Figure 5 KASPeR system design



Source: Geodetic institute of Slovenia

3.3 Next steps

Ambitions regarding the future development of the integrated system for the dissemination of geostatistical data at SURS as well as the expectations of the users are great, especially after the successful implementation of KASPeR which is, as mentioned, focused on 2011 census data. The system is being upgraded in the framework of the three tier project performed by SURS and external partners, of which the Geodetic Institute of Slovenia is in charge of the development of a new web mapping application that will substitute the existing KASPeR in 2014.

Tier A covers the development of a new interactive application for viewing and downloading geostatistical data and is co-financed by the Eurostat's grant "Merging statistics and geospatial information in Member States". The new application will cover a significantly larger set of variables from various statistical domains and will include the time dimension introduced by a time slider. A major improvement will be the administrative interface that will enable automated data input directly from the main official statistical database SI-STAT which is built in the PC-Axis environment. Another important new feature of the user interface will be the delineation tools that will enhance the user experience by allowing the users to define their own area of interest either from administrative units, grids or addresses. The application is also expected to graphically complement other SURS' dissemination products that are mainly

presented in textual format. INSPIRE standards regarding the network services will be implemented as well including:

- discovery services,
- view services,
- download services,
- transformation services.

Tier B is being performed by SURS and deals with the upgrade of the GIS database. Improvements will be made regarding the enlargement of the set of variables that will be provided for available time series and geo-spatial datasets defined in two national and one European (ETRS89/LAEA) projections. The set of variables will follow the recently adopted policy that the users should have free access to all relevant statistics also in formats directly applicable to further handling in GIS. Tier C thus demands a thorough study of available statistics provided either by SURS or other producers of official statistics that have a potential and relevancy to be presented as geo-spatial statistical data. Besides the defining of the set of variables, the focus of this Tier is also on defining the confidentiality rules that will determine the level of disclosure as well as the spatial accuracy of the data.

CONCLUSION

Activities described follow the decades of successful work done by SURS and other institutions towards the integration of geography and statistics. Establishing of the Register of Spatial Units and its integration into the statistical process enables various cartographic presentations of statistics and also their application to web mapping visualisation tools. SURS is committed to continue creating new geo-statistical products and improving the system for their dissemination as well as to share the professional experience and integrate national dissemination systems into international infrastructures. Development of a new web mapping application in 2013 that is going to substitute KASPeR will round off the SURS's efforts to establish a user-friendly application that would serve as a viewer and access point for geo-statistics and will be a great upgrade of the existing services joint under SURS's Geostatistics portal.

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Recent Publications and Events

New Publications of the Czech Statistical Office

Adult Education Survey 2011. Prague: CZSO, 2013.

DUBSKÁ, D. *Domácnosti v ČR: příjmy, spotřeba, úspory a dluhy v letech 1993 až 2012* (Households in CR: Income, Consumption, Savings and Debts in the Years 1993–2012). Prague: CZSO, 2013.

Expeditures and Consumption of Households Included in Household Budget Survey in 2012. Prague: CZSO, 2013.

Household Income and Living Conditions 2012. Prague: CZSO, 2013.

Other Selected Publications

20 let samostatného Česka a Slovenska: Porovnání jejich ekonomického vývoje a pozice v EU (20 Years of the Independent Czech Republic and Slovakia: Comparison of their Economic Development and Position in the EU). Brno: NEWTON College, a. s., 2013.

BELL, W. R., HOLAN, S. H., McELROY, T. S., eds. *Economic Time Series. Modeling and Seasonality.* NY: CRC Press, 2012.

ČEŠKA, J. *Czechoclovakia. Czech and Slovak Federal Republic. Survey of Official Statistics in 1980–1992. Part I.* Prague: FUTURA, 2013.

DOBRINSKI, R. What is Happening to Growth in Europe? *Research Reports,* 385, The Vienna Institute for International Economic Studies, Vienna, February 2013.

EUROSTAT. *Taxation Trends in the European Union*. Luxembourg: EU, 2013.

GOOD, P. I. *A Practitioner´s Guide to Resampling for Data Analysis, Data Mining, and Modeling.* NY: CRC Press, 2012.

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POHLOVÁ, K. *Agrarian Foreign Trade Yearbook 2012.* Prague: Institute of Agricultural Economics and Information, 2013.

Selected Data on Housing 2011. Prague: Ministry of Regional Development of the CR, Institute for Spatial Development, 2012.

Yearbook of Tourism Accomodation and Catering of the Czech Republic and Slovak Republic. Prague: MAG CONSULTING, s. r. o., 2013.

WHO. *World Health Statistics 2013.* Geneva: WHO, 2013.

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Conferences

The ***59th World Statistics Congress (WSC)*** took place during ***25–30 August 2013 in Hong Kong, China.*** The ISI World Statistics Congress, formerly known as ISI Sessions, takes place once every two years in a different country and is organised with the host country's central bureau of statistics. More information available at: *http://www.isi2013.hk/en/index.php*.

The ***16th International Scientific Conference AMSE 2013 (Applications of Mathematics and Statistics in Economy)*** was held ***from 28 August to 1 September 2013 in Gerlachov, Slovakia.*** AMSE 2013 was organized by the University of Economics, Prague, Czech Republic (Faculty of Informatics and Statistics, Department of Statistics and Probability), Matej Bel University, Banská Bystrica, Slovakia (Faculty of Economics, Department of Quantitative Methods and Information Technology) and the Wroclaw University of Economics, Wroclaw, Poland (Department of Statistics). More information available at: *www.amse.umb.sk*.

The ***31st International Conference on Mathematical Methods in Economics*** took place during ***11–13 September 2013 in Jihlava, Czech Republic.*** The conference was held under auspices of the College of Polytechnics Jihlava, Czech Republic, the Czech Society for Operations Research, the Slovak Society for Operations Research and the Czech Econometric Society. More information available at: *https://mme2013.vspj.cz*.

The ***7th International Days of Statistics and Economics (MSED)*** was held during ***19–21 September 2013 at the University of Economics, Prague, Czech Republic.*** The Conference was organized by the University of Economics, Prague, Czech Republic (Department of Statistics and Probability and the Department of Microeconomics), the University of Economics with seat in Košice, Slovakia (Faculty of Business Economics) and the ESC Rennes International School of Business, France. More information available at: *http://msed.vse.cz*.

The ***10th Applied Statistics 2013 Conference*** took place during ***22–25 September 2013 in Ribno, Slovenia.*** The Conference was organized by the Statistical Society of Slovenia and the University of Ljubljana in cooperation with the Statistical Office of RS. More information available at: *http://conferences.nib.si/AS2013*.

Papers

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