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Hungary's Price and Wage Level in International Comparison: Are They Really Disconnected?*

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It is often claimed that Hungary's price level has almost reached that of the more developed member countries of the European Union, while wages lag behind both the relative level of prices and the economic performance of the country. The article shows that these notions are based on misperceptions and misinterpretations, related to the selective comparison of prices and to methodological problems in wage-comparisons. If adequately compared, the level of Hungary's prices turns out to be somewhat lower than justified by per capita real gross domestic product, while the level of Hungary's labour costs, adjusted for differences in price levels, is in line with the country's labour productivity. Though the article focuses on Hungary, most of the issues discussed are relevant for the other Central and East-European member countries of the European Union, too.

KEYWORDS:
International comparison.
Levels of economic development.
Relative wage and price levels.

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The relative level of prices and wages of a less developed country, as compared to more affluent nations, is an important and politically sensitive topic, often abused by populist politicians. This article, after providing some examples of political misuses, tries to explain why some common perceptions regarding "too high prices" – involving "too low wages" of citizens – of a less developed country may be flawed. The examples relate to Hungary, but most of the issues discussed are relevant for the other Central and East-European member countries of the EU[1] as well.

In the next section, some typical political slogans are cited, followed by the discussion of a sort of "spatial" money illusion. Next, the level of Hungarian prices is compared to the more developed part of the EU, relying on the cross-country relationship between economic development, price levels and the relative price between services and goods. The final section deals with the comparison of nominal and real wages (the former is measured in euros, the latter at PPP[2]). Seemingly, it makes a fundamental difference, whether wages measured at current exchange rates or at PPPs are compared to real productivity. However, as to be shown, the two approaches can be reconciled, and neither of them indicates that the Hungarian wage level lags behind the labour productivity of the country.

1. Wage and price levels: the political slogans

During the European Parliament election, several political parties placed slogans related to wages and prices on their posters, such as "European wages for European work!" or "We want European salaries, not just European prices!" Another, less combative slogan was "The work of a Hungarian employee in Kecskemét is worth just as much as the work of an employee at any other Mercedes plant. Let us close the EU-Hungarian wage gap!"

The first slogan is built on a statistical flaw, while the second derives from an economic misunderstanding and a statistical flaw. The problem with the third one is that the wage gap across Mercedes plants is irrelevant regarding the possibilities of convergence in the overall Hungarian wage level to the EU average.

It is to be shown in connection with the first slogan that "Hungarian work" is far from being "European" in the sense that its average productivity – measured by

[1] EU: European Union.
[2] PPP: purchasing power parity.

GDP[3] per hour worked – was only 53 percent of the average of the Western European member countries in 2012–2013. (By "Western Europe" we refer to the EU15[4], the members of the EU before the enlargement of 2004.) Therefore, the demand that Hungarian wages be raised to the (West-) European level is unjustified. The theoretical problem with the second slogan is that price convergence has no direct relationship with comparative wage levels. If Hungarian productivity is approximately half of the Western European average, then euro wages cannot be much higher than half of the latter, even if the respective price levels were identical. This misunderstanding is compounded by a statistical flaw: domestic prices are still far below that of the EU15. In 2013, the price levels of GDP, total household consumption and household consumption expenditures stood at 54, 51 and 56 percent of the EU15 average, respectively. As for the third slogan, Mercedes chose Hungary as a production location because Hungarian prices, and – partly due to this – Hungarian wages are lower than in the home country of the firm. The average wage level in the Mercedes plant in Kecskemét, however, is very likely to be far above the national average, just as in many other foreign-owned companies.[5] If, from another standpoint, the wages in the Hungarian Mercedes plant were raised to the wage level in Germany, forcing all the other firms to follow suit, this would lead to severe layoffs, since the bulk of domestic firms, operating at a much lower level of productivity, would be unable to offset the higher cost of labour.

How such slogans, fraught with theoretical and statistical fallacies, can be disseminated in public? The most likely explanation is that the experts of the political parties and the originators of slogans themselves are influenced by the same illusions as the majority of their voters.

2. Price levels, relative prices and income levels in international comparison

In the following section, I will first try to demonstrate how a sort of money illusion may lead to flawed international comparisons. Second, I provide an overview of the theoretical and empirical links between price levels and relative prices on the one hand, and levels of economic development on the other.

[3] GDP: gross domestic product.

[4] EU15: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal, Spain, Sweden and the United Kingdom

[5] As shown by *Earle–Telegdy–Antal* [2012] for foreign-owned companies in general and by *Soós* [2013] for foreign-owned exporting companies in particular, the wage level at these companies is far above the national average. The wages in the Mercedes plant are unlikely to be exceptions of this general pattern.

2.1. Spatial money illusion

Whether the so-called money illusion has a macroeconomic relevance via its influence on personal decisions is a disputed issue. Money illusion is the failure to perceive nominal magnitudes (measured at current prices) as clearly distinct from "real" ones (adjusted for price level changes).[6] A frequently cited example of money illusion is the observation that employees tend to be more willing to accept a decrease in their real wages because of a rise in inflation than due to a cut in nominal wages. Several explanations of money illusion exist: one of them is that people generally perceive changes in the prices of goods and services purchased daily more acutely than changes in the prices of less frequently purchased goods and services, involving larger expenditures. As an analogy of this intertemporal money illusion – the erroneous perception or ignorance of price changes – "spatial money illusion" can be understood as a tendency to misperceive or ignore the existing price level differences between countries.

Hungarian tourists visiting Western Europe may be led astray by this type of money illusion, relying solely on the price tags displayed in the shopping centres. Somewhat similar illusion characterises those Hungarian economists, who – while claiming that "we have reached European prices" – fail to notice, due to the careless or selective inspection of comparative price statistics, that an average earner from Hungary would suffer a deep fall in living standards, if having to live in Western Europe from the salary received at home. As it can be seen from the first row of Table 1, the average price level of household consumption expenditures in 2013 was nearly 80% higher in the developed EU member countries than in Hungary.[7] The impact of this price differential on the purchasing power of Hungarian consumers is represented by the second column of Table 1 that shows how many forints our one hundred forints earnings would have been worth if we had tried to live from it in Western Europe. In 2013 each 100 forint of our net salary was worth 56 forints in the EU15, implying a potential loss of purchasing power by 44%.

It can also be seen from Table 1 that price levels are far from uniform within the EU15.[8] In Denmark, for example, the purchasing power of our domestic income

[6] The book of *Fischer* [1928] is widely regarded as the classic exposition of money illusion. Although modern macroeconomic theory, being based on the assumption of rational expectations, posits the impossibility of this phenomenon, *Akerlof–Shiller* [2009] demonstrated that its ignorance often makes the actual evolution of modern economies incomprehensible. Nevertheless, even if economic agents do fall prey to money illusion, economic analysts must not: for an adequate analysis, the clear distinction between nominal and real quantities is a vital requirement. For a further discussion of money illusion, see *Shafir–Diamond–Tversky* [1997].

[7] 1/0.562 =1.78 where the 56.2 percent is the Hungarian price level of household final consumption expenditures compared to the EU15 price level. See the first row of Table 2.

[8] Important reasons of the variation in price levels are the significantly differing average value-added tax rates and the difference in the value-added tax rates imposed on main expenditure items. This should be taken into account while interpreting the comparisons provided by Table 2.

would have fallen by almost 60 percent in 2013, while in the UK and in Germany, it would have declined by approximately 50 and 40 percent, respectively. It is not by accident that Hungarian retired citizens do not try to live off their pension in the Nordic countries but the opposite is quite common. (As the table shows, the latter countries have the highest price levels in the EU.) The Western European senior citizens coming to live in Hungary do not suffer from money illusion: they know that the purchasing power of their pension may even double if they spend it in Hungary, instead of their home country.

Table 1

The price levels of household consumption expenditures in the EU15, compared to Hungary, 2013

Group of countries/ Country	Price level of household consumption expenditures (Hungary = 100%)	Purchasing power of 100 forints received in Hungary (HUF)
EU15	178	56
Belgium	183	55
Denmark	234	43
Germany	170	59
Ireland	198	50
Greece	150	67
Spain	159	63
France	183	55
Italy	173	58
Luxembourg	207	48
Netherlands	185	54
Austria	179	56
Portugal	144	69
Finland	207	48
Sweden	217	46
UK	190	53

Source: Here and in Table 2 as well as in Figures 1–3, own calculation based on Eurostat data.

2.2. Relative consumer price levels and relative prices

Table 2 shows the price level of selected commodity groups and basic services in Hungary and some developed EU member countries in percent of the EU15 average.

These comparisons may provide some clues regarding the fallacy that the Hungarian price level has already caught up to that of Western Europe. As shown in the table, the Hungarian price level of food, clothing and especially electronic equipment is quite close to that of the more developed part of Europe. As a result, a Hungarian visitor in Western Europe, who only compares the prices of these goods, is likely to fail to perceive that the overall price level is much lower in Hungary than in the countries compared.

However, when after asking friends or relatives who live and work in Western Europe about their monthly housing expenses (rent, energy, etc.), one may get a completely different picture, supported by the figures in Table 2. In Western Europe, the price of these services is double and half the level in Hungary; triple in the UK, 3.5 times higher in Denmark. (The share of housing costs within overall household expenditures is nearly one-fourth in Hungary; in Western Europe, it is somewhat higher.) A comparison of relative prices highlights a clear pattern: in Hungary, the prices of goods are much closer to Western European levels than the prices of services. In 2013, the price level of the former reached 72% of the EU15 average, while the respective ratio for consumer services was only 44%. The weighted average of the two gives 56% for the overall relative price level of household consumption expenditures, which is rather far from being "European".

Table 2

Price levels of household final consumption expenditures and their selected components in Hungary and six Western European countries, 2013

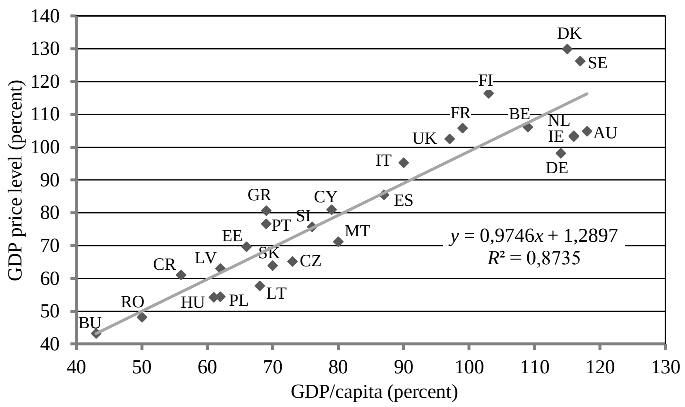
(EU15 = 100%)

Consumption aggregates	Hungary	Austria	Denmark	UK	Finland	Ireland	Germany
Household final consumption expenditures total	56.2	100.7	131.6	106.9	116.3	111.3	95.6
Consumer goods	72.3	102.5	127.4	99.0	111.3	110.3	99.2
Food	74.3	115.3	127.8	93.0	115.3	108.7	101.8
Clothing and footwear	75.6	97.9	124.0	92.3	118.7	97.0	101.5
Audio-visual, photographic and information processing equipment	93.5	94.8	111.9	101.6	107.9	104.3	93.9
Consumer services	44.3	98.5	135.6	115.1	121.8	112.3	93.3
Housing, water, electricity, gas, other fuels	38.3	86.9	133.8	124.4	114.3	105.5	95.3

2.3. Relative price level and the relative level of economic development: theory and evidence

The relationship between price levels and economic development – that is, the observation that relative price levels (measured in a common currency) between countries tend to rise along with the relative level of economic development – was modelled by *Balassa* [1964] and *Samuelson* [1964]. The more developed a country is economically – that is, the higher its GDP per capita or GDP per hour worked is – the higher the price level of GDP will be, and vice versa: the less developed the country is economically, the lower its price level is.[9] Figure 1 shows the price level of GDP of 27 EU member countries as a function of GDP per capita, expressed in PPP, for 2013.[10]

Figure 1. The price level of GDP as a function of GDP per capita in the EU member countries, 2013
(EU15 = 100%)



Note. The price level of GDP (P_GDP) is compared to the EU15 average. P_GDP = 100 × (PPS^{11}/E) where *PPS* is the purchasing power parity construed by the Eurostat (in the figure: as a percentage of the EU15 average) and *E* is the currency exchange rate. For the EU15 as a whole, 1 *PPS* = 1 euro in the cart; for the Eurozone members, *E* = 1. See the country codes stipulated by EU rules at http://publications.europa.eu/code/en/en-5000600.htm

The data demonstrate a very close relationship between the levels of economic development and price levels. On average, a 1-percentage point higher/lower level of

[9] To put it differently: the proposition of the purchasing power parity theory that the equilibrium level of the exchange rate is determined by the purchasing power parity is not valid if the currencies in question belong to countries at different levels of economic development. The currencies of less developed countries are undervalued relative to their purchasing power parity, and the extent of currency "undervaluation" in this sense is an increasing function of the relative underdevelopment of the country.

[10] Luxemburg is not included in the comparisons, since its small size is combined with extreme values.

[11] PPS: purchasing power standard.

per capita GDP roughly involved a 1-percentage point higher/lower relative price level.[12] The price level in Hungary – like in Poland – was below the regression line in 2013, that is, it was slightly lower than warranted by its relative development level. With the GDP per capita reaching 61% of that of the EU15, the price level, expressed in euro, should have been higher by approximately 6.5 percentage points (10 percent) to be in line with the relative development level. This suggests that the forint may have become undervalued by 2013.

Balassa [1964] explained the relationship shown in Figure 1 by the difference between the productivity of tradeable and non-tradeable sectors, but his model was based on a number of restrictive assumptions. His explanation, partly due to these assumptions, has turned out to be highly controversial, and many questioned even the existence of the relationship itself. In an attempt to make a clear distinction between the statistical observations and their possible explanations, *Samuelson* [1994] coined the statistically observed phenomenon as the "Penn effect". The name is a homage to the Penn World Table, the national accounts dataset covering most countries (originally linked to the University of Pennsylvania[13]) that was instrumental in identifying the close empirical relationship between differences in per capita incomes and price levels, for which the Balassa-Samuelson hypothesis is a possible, although not the only and not always valid explanation. The Penn effect in itself, however, to quote Samuelson, is a "brute statistical fact" even if the assumptions of the Balassa model turn out to be unrealistic, or if alternative explanations – for example, the one based on the differences in factor intensities of goods and services (*Bhagwati* [1984]) or on the different income elasticities of demand for goods and services (e.g. *Podkaminer* [2010]) – turn out to have more explanatory power.[14]

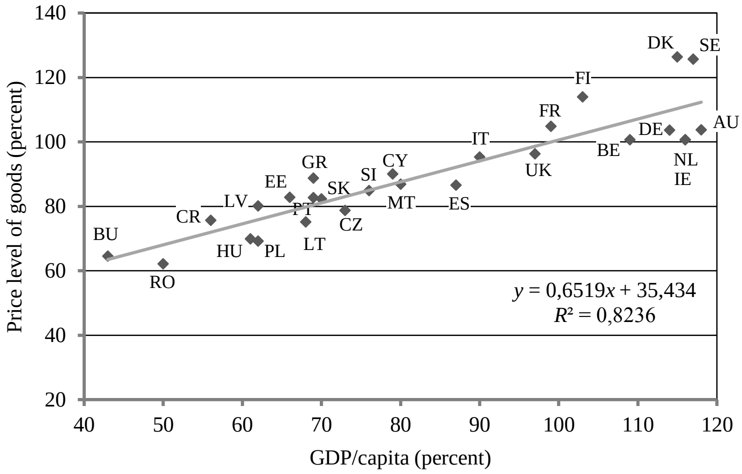
While Figure 1 shows that the Penn effect was operative among the EU member countries (significant price level differences came with considerable income differences), Figure 2 suggests that this can mostly be explained by the substantial variation in the price of services. Comparing the two sides of the figure shows that the variation in the price levels of goods (as a function of relative GDP/capita levels) is much less pronounced than that of services. Even if the prices of goods are far from being equalised internationally (as assumed by Balassa's model), the regression line expressing the association between service prices and income levels is much steeper than the one expressing the relation between the prices of goods and levels of income.

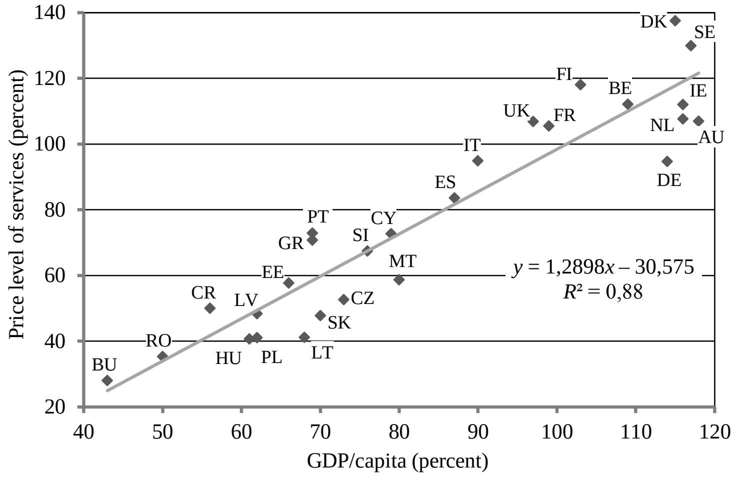
[12] The relationship between the two variables remains close if alternative years – or a period of several years – is chosen as reference period instead of 2013. The value of the regression coefficient in Figure 1 – 0.975 – is statistically significant at the 0.01 level.

[13] As of 2013, the "next generation" of the Penn World Table is maintained by the *University of Groningen* [2013].

[14] According to *Samuelson* [1994]: "A reliable fact that is not provided with an explanation is better than a nice theory that helps explain and understand an *untrue fact*." (p. 205.).

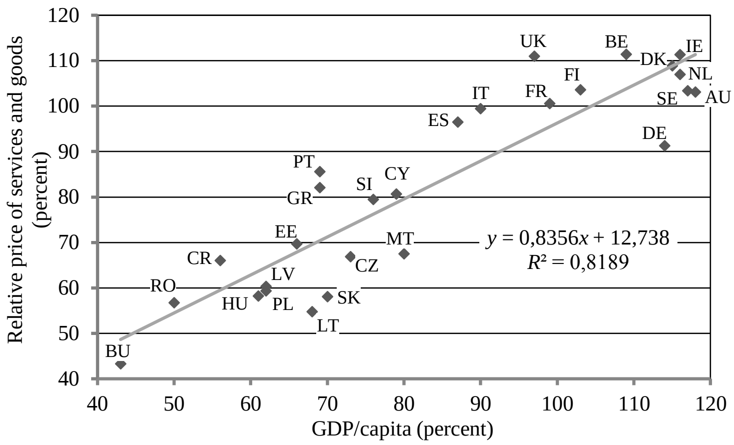
Figure 2. The price level of goods (above) and services (below) as a function of GDP per capita in EU member countries, 2013
(EU15 = 100%)





We have seen in Table 2 that in Hungary the price level of consumer services, as compared to the more developed EU countries, is lower than that of consumer goods. Figure 2 shows that this is not a Hungarian peculiarity; it closely corresponds to an EU-wide pattern. Namely, in countries with lower-than-average GDP per capita, the relative price level of services is lower than that of goods, and this applies not just to consumer goods and consumer services but also to goods and services in general. Figure 3 shows the "internal relative price" of services – that is, the price of services relative to the price of goods – as a function of relative income levels.[15] It informs about the domestic background of the relationship between the price level and the per capita volume of GDP, demonstrating that the phenomenon shown by Figure 1 can chiefly be explained by the cross-country differences in the internal ratio of the price level of services to that of goods. It is important to note, however, that only the substantial differences can be explained that way, since, as presented by Figures 1 and 3, this EU-wide pattern is far less discernible within the groups of countries at a similar level of economic development.

Figure 3. The relative price of services and goods as a function of GDP per capita in EU member countries, 2013
(EU15 = 100%)



The relative price featured in Figure 3 is similar to the so-called "internal real exchange rate" (see, for example, *Égert–Halpern–MacDonald* [2006] and *Ruscher–Wolff* [2009]). This relative price has a definitive impact on the relative domestic demand and profitability (therefore, supply) of tradeables and non-tradeables (services dominate the latter), and as a result, the foreign trade balance as well. An above-equilibrium level of the relative price of services is seen as an indicator of overvalued currency, possibly leading to a foreign trade deficit, while the opposite is seen as a sign of under-

[15] The internal relative prices displayed in Figure 3 show the ratio of the two external relative price levels, that is, the ratio of the respective price levels of goods and services relative to the EU15 level (the two sides of Figure 2). Construing such a ratio is not a methodologically perfect exercise, since a different set of purchasing power parities is required for the comparison of within-country price structures than the purchasing power parities used by the Eurostat for cross-country price level comparisons. Price structure comparisons based on the alternative, so-called Geary–Khamis-type purchasing power parities were last published in 2008 by the Organisation for Economic Co-operation and Development, and for most countries, the two methods of calculation did not produce substantially different internal price structure figures. For a discussion of the two types of purchasing power parities and their uses, see *Eurostat–OECD* [2012].

valued currency that can generate foreign trade surplus. If we define "equilibrium" as points lying on the cross-country regression line, and assume that divergences from the regression line in Figure 3 (i.e. the residuals of the regression) indicate the extent of misalignment, then the Hungarian forint was undervalued by about 8 percent in 2013. This estimate is in line with the 10 percent undervaluation indicated by Figure 1, but it is also corroborated by the fact that Hungary was pretty much an outlier among the EU member countries in 2013 with its external trade surplus up to 8% of GDP. All this suggests that the forint was somewhat undervalued in the year of our observation and it is not a minor detail regarding the question of whether the Hungarian wage level is unreasonably low relative to the EU15 wage level.

3. Nominal and real wage levels in international comparison

Concerning relative wage levels, we can often hear arguments like the following: „At present, Hungary's economic performance stands at around two-third of the EU average, yet our wage level is barely above one-third of the EU average. Therefore, it is just not true that our wages are so low because our economic performance is so poor." (*Molnár* [2014]).

This reasoning suffers from a methodological mistake, frequently made not just by politicians but also by economists: contrasting relative economic performance measured at PPP (that is, in real terms) with relative wage levels measured in euros (i.e. in nominal terms). Those, who make such comparisons, see through the "veil" of nominal magnitudes regarding economic performance (and compare volumes) but fall into the trap of "spatial money illusion" – to use the term proposed earlier – when dealing with relative wage levels, by comparing nominal magnitudes expressed in euros.

I proceed by first examining the international comparability of net wages and labour costs. After this, I outline two theses.

> *1*. If we wish to obtain direct and easy-to-interpret information regarding the relationship between economic performance and wage levels, that is, to make a judgment on whether the relative wage level in a given country is in line with its relative level of development, we can choose between two, equally applicable methods: we *a)* measure both economic performance and wages in real terms (PPP) or *b)* compare nominal quantities expressed at current exchange rates (in the case of European comparisons in euros).

2. It is not pointless to relate euro-denominated wage levels to real economic performances in a cross-country comparison. To do this in a meaningful way, it is essential to comprehend the nature of the economic relationship between the two. As we will see, none of these two approaches confirms the claim that Hungarian wages are "lagging behind".

3.1. From net wages to labour costs

Comparing wage levels internationally is a much less straightforward task than comparing price levels. Wages can be interpreted as costs (from the perspective of employers) and as income (for the employees). Comparing wages as costs and as incomes, however, can lead to different results. From the employers' perspective, gross compensation (labour cost) is the relevant indicator – this is what affects the profitability and cost-competitiveness of production. For employees, in turn, the level of net earnings is relevant: this determines income available for either consumption or savings. To make international comparisons regarding real wages defined in one way or the other, different cross-country price level indices (PPPs) are required. For comparing "producer real wages", price level indices for production (i.e. that of GDP) should be applied, while "consumer real wages" ought to be compared by using the price level index for household consumption expenditures.

However, if comparison of wages is a more complex task than that of prices, it is yet more challenging to compare net wages than labour costs in an international context. While the concept of average labour cost has a more or less straightforward meaning and can be connected to specific statistical data, net wages represent a different case. The empirical content of the latter depends on several factors, like the level of income and family size. It is no accident that the Eurostat publishes data for average labour costs[16] but not for average net wages. Instead, it provides data for net wages received by certain categories of wage earners, differentiated by income level and family size.[17] Moreover, these numbers reflect only the impact of taxes, tax breaks and social security contributions, but they do not take into account social transfers in kind received (public education, public health care).

These conceptual problems and measurement difficulties notwithstanding, I present a very simple and admittedly rough set of estimates for the comparative levels of net wages and gross labour costs in Hungary, in both euro and PPP terms in Table 3. The EU27 average levels in 2012 serve as the reference for comparison, but indi-

[16] Eurostat database: Labour cost levels (lc_lci_lev). http://ec.europa.eu/eurostat/web/labour-market/labour-costs/database

[17] Eurostat database: Annual net earnings (earn_nt_net). http://ec.europa.eu/eurostat/web/labour-market/earnings/database

ces relative to the EU15 average and for the year 2013 are also featured if the statistics are available.[18] The first block of the table (rows 1–4.2) displays nominal (euro-denominated) ratios, the second block (rows 5–6) shows the price indices needed for the conversion of the nominal values to real magnitudes, while the relative real levels can be seen in the third block (rows 7–10.2).

The comparative level of real household consumption along with its two components – household consumption expenditures and social transfers in kind from government – are also shown in the table as memorandum items.

In the following, I focus on that column of the table, which shows Hungarian levels relative to the EU27 in 2012. The nominal (euro-denominated) GDP per capita, the GDP per hour worked and gross hourly labour costs, as a percentage of EU27 average, stood at 38.5, 34, and 32 percent, respectively. The relative level of productivity (GDP per hour worked) lagged behind the relative level of economic development (GDP per capita), while the former only slightly differed from the relative level of hourly labour costs. The level of net earnings of the various categories of earners were spread between 24.5 and 31.5 percent of the EU27 average; that is, even the relative net wages of the comparatively highest earners fell below the average relative level of labour costs. This suggests that the comparative level of Hungarian gross labour costs is roughly in line with labour productivity, but relative net wages are below this level.

The relative real (PPP-denominated) magnitudes are obtained by applying the cross-section price level indices shown in the second block of the table. These real (volume) figures indicate – in accordance with the nominal ones – that the producer real wages are only slightly lower than real productivity. By contrast, net real wages, while varying in wide range (between 41 and 53% of the EU27 average), fall behind, even at their highest, from the relative level of productivity. These figures, however, should be interpreted in light of information on per capita social transfers in kind, shown among the memorandum items in Table 3. The volume of this transfer stands at 80 percent of the EU27 average, far above per capita GDP or productivity. (See the 7th, 8th and 11.1th rows in the table). As a result, the real level of actual household consumption (11th row) is, by and large, in line with Hungary's economic performance: between the comparative level of the productivity and income (GDP/capita) of the country.[19]

Next, I examine the link between productivity and labour costs, based on the data on EU member countries, in order to clarify whether Hungarian labour costs should be seen as below par when compared with Hungary's economic performance.

[18] The Eurostat does not provide hourly labour cost data regarding the EU15 average and Croatia; at the time of writing, data on the average labour cost in the EU27 in 2013 were also unavailable.

[19] A similar pattern can be seen in the other former socialist EU member countries as well: the range of net wages is at a relatively low level, while the level of social transfers in kind is remarkably high as compared to that of economic performance and productivity.

Table 3

Selected indicators of economic performance and wage levels in Hungary,
as a percentage of the average levels in the EU15 and EU27, 2013
(percent)

Indicator	2012	2013	2012	2013
	EU15 = 100		EU27 = 100	
	Nominal levels (euro)			
1. GDP per capita	33.0	33.0	38.5	38.5
2. GDP per hour worked	28.5	28.5	34.0	34.0
3. Real labour cost	–	–	32.0	31.0
4. Net real wage				
4.1. Lowest*	21.0	–	24.5	–
4.2. Highest*	27.0	–	31.5	–
	Price level indices (PPS/E)**			
5. GDP	54.1	54.2	57.4	57.5
6. Household consumption expenditures	56.8	56.2	60.2	59.6
	Real levels (PPP)			
7. GDP per capita (7. = 1./(5./100))	61.0	61.0	67.0	67.0
8. GDP per hour worked (8. = 2./(5./100)	53.0	53.0	59.5	59.5
9. Real labour cost (9. = 3./(5./100))	–	–	56.0	54.0
10. Net real wage				
10.1. Lowest* (10.1.= 4.1./(6./100)	35.0	–	41.0	–
10. 2. Highest* (10.2.= 4.2./(6./100)	44.5	–	53.0	–
	Memorandum items (real consumption per capita, in purchaser power parity)			
11. Actual consumption of households	58.0	58.0	63.0	63.0
Of which:				
11.1. Consumption expenditures	54.0	54.0	59.0	59.0
11.2. Social transfers in kind	75.0	75.0	80.0	80.0

* The minimum and maximum levels out of the thirteen categories (by income and family size) featured in the Eurostat database.

** The Eurostat provides figures to one decimal only for price level indices; I have rounded the other figures to half decimal places.

Source: Here and hereinafter, own calculation based on Eurostat and AMECO databases.

3.2. Nominal and real labour costs

To start with, it might be useful to summarise the reasons why it makes more sense to compare productivity levels with gross labour costs rather than with net earnings. This is important since the slogans quoted earlier in the article may refer to labour costs and net wages alike. However, it is extremely difficult to make quantitative statements regarding the latter for the following reasons.

> – There are no internationally comparable data on the subject of national averages for net wages (the Eurostat does not provide weights for the 13 income/family subgroups).
>
> – Net wage numbers do not mean much in themselves (without taking into account the real value of social transfers in kind), but the per capita volume of the social transfers in kind cannot be linked in any meaningful way to the available net wage data.
>
> – While the concept of GDP per hour worked is directly comparable to that of hourly labour costs, it would be highly problematic to compare annual net wages per income earner (for which the data do not actually exist) to GDP per hour worked.

Let us have a look on the indicator that has the properties for proper international comparison. According to Eurostat data, Hungarian gross labour costs per hour worked stood at 7.5 and 7.4 euros in 2012 and 2013, respectively, which corresponded to 31-32% of the EU27 average. Is this ratio high or low, or is it just about right in light of the 60% relative productivity level of the country (or 53%, if compared to the EU15)? As emphasised previously, the simple nominal (euro) 30% and real (PPP) 60% comparison is unsuitable to arrive at meaningful conclusions. However, no one can predict whether the nominal or real comparison of the two ratios will be more fruitful. This is why, as a first step, it is useful to have a look at the cross-section productivity/labour cost relationship among the 26 member countries in both euro- and PPP-terms. [20]

The nominal comparison, shown in the upper part of Figure 4, suggests a strikingly strong relationship between euro labour costs and productivity levels expressed in euros: the rise in current price productivity by one percentage point involves a rise in labour costs by 0.3 euro.[21] The data point of Hungary lies on the regression line, that is, the euro labour cost in Hungary is in line with the EU-wide cross-country

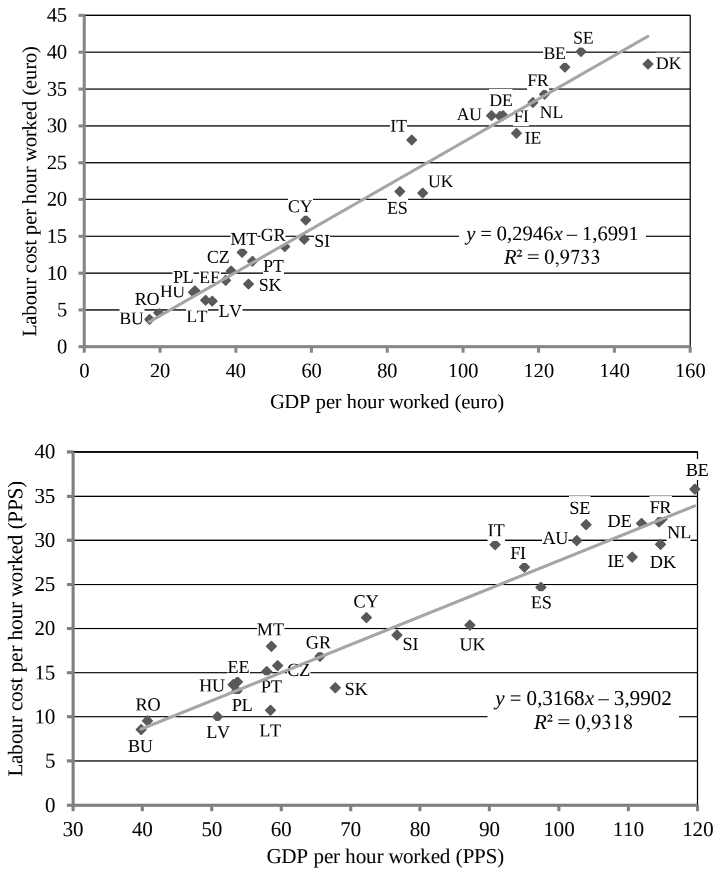
[20] Croatia is left out from the following figures, as the AMECO database does not contain productivity data on the country.

[21] In terms of relative levels (the correlation of logarithms), with a rise of 1 percent in euro productivity comes the rise of 1.1 percent in euro-denominated labour costs.

productivity/labour cost relationship. The lower part of the figure displays the national productivity/national labour cost connection in real terms, i.e. adjusted for the differences in price levels. Again, the relationship is quite strong, and the producer real wage in Hungary is in line with its comparative productivity level. This does not apply for some of the other new member countries (Latvia, Lithuania, and Slovakia) whose data points lie well below the regression line.

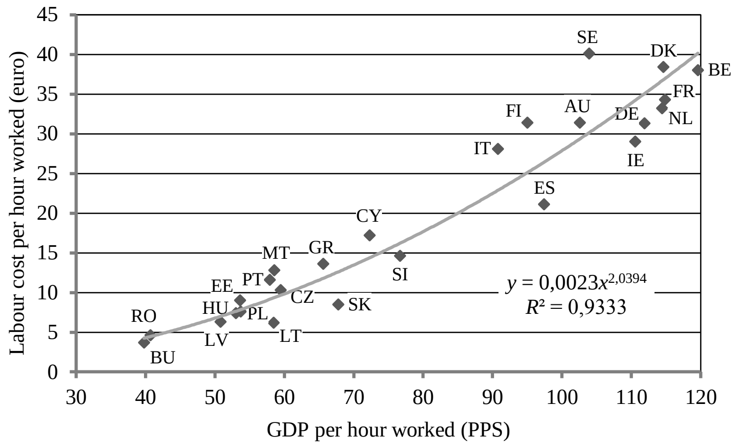
Figure 4. Labour costs and productivity measured in euro (above) and purchasing power parity (below) in 26 EU member countries, 2013

(EU15 average = 100%)



Finally, let us examine the often-cited relationship between euro wages and real productivity, which has been claimed to demonstrate that wages are lagging behind in Hungary. The horizontal axis of Figure 5 shows the relative real productivity, while the vertical axis illustrates labour costs in euros.

Figure 5. Nominal hourly labour costs and the volume of GDP in 26 EU member countries, 2013



It can be seen that the best fit expressing the relationship between nominal wages and real productivity is not a linear but a quadratic regression curve. The explanation is that the nominal (euro) wage cost can be decomposed into the product of the producer real wage in PPP (see Figure 4, lower part, vertical axis) and the price level index of GDP (see Figure 1, vertical axis),[22] and both are closely related to the level of real productivity, with coefficients close to 1. In Figure 5, just as in the previous ones, the data point of Hungary lies very close to the regression curve, which suggests that, if conducted properly, the comparison of nominal wages and real economic performance indicates no disconnection between the two. It should be noted, however, that if the roughly 5-10 percent undervaluation of the forint was eliminated, wages expressed in euro would rise at a similar rate, and this level would still be in line with real productivity.

4. Conclusion

In this article, I demonstrated that common notions and political slogans expressing the perception that Hungary's prices are too high, while wages are too low as compared to the country's real economic performance, are based on illusions and convey further illusions. They carry the false promise that Hungarian wages could be

[22] Formally: NLC(*i*)/NLC(*eu*) = RLC(*i*)/RLC(*eu*)*PLI(*i*) where NLC, RLC and PLI, respectively, denote nominal labour cost (in euro), real labour cost (in PPP) and the price level index (the ratio of PPP to the exchange rate). The subscript *i*, denotes the i^{th} EU member country and *eu* refers to the EU-average.

raised significantly without substantial convergence in the level of the country's productivity. What Hungary – similarly to other new EU member countries – really needs is a long-term strategy fostering the growth of productivity, as this provides the only solid basis for longer-term wage convergence to the level of the more advanced countries of the European Union.

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Modelling Non-Equidistant Time Series Using Spline Interpolation*

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This study gives an overview of spline interpolation, a special class of interpolation methods. The focal concern discussed in this paper is that the augmentation of non-equidistant time series (using averages, previous values, or interpolation) often leads to misleading or erroneous conclusions, as the augmented time series may have different characteristics than the original data generating process. The author's main purpose is to demonstrate that augmentations of any kind are to be planned carefully. To underline this statement, he applies the most frequently used methods on empirical time series, then collects and highlights the most prevalent conclusions.

Keywords:
Time series analysis.
Interpolation.

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The vast majority of literature addressing time series analysis focuses on uniformly spaced events, where the gaps between observations are of equal lengths. In such cases, the specific times or dates of the observations do not need to be recorded, as we can retain all information by only indicating the time of the first and last observations, along with the frequency of occurrences. These data sets are often referred to as equidistant time series, where the times or dates of observations are typically replaced with consecutive integers ($t = 1, 2, \ldots, T$) without losing any information.

However, time series analysis is not limited to such "ideal" cases, as the lengths of gaps between observations may vary. Financial markets, among many other fields within economics, are a great example: price charts often include gaps of different lengths, due to the presence of weekends and national holidays, but it is even more prevalent on intra-day levels as nothing guarantees that market transactions would take place at a regular pace, say, every 10 or 20 seconds. In macro-level demand models, for instance, non-observable (latent or induced) demand is often replaced with unequally spaced purchases.

Marine biology, astrophysics and meteorology apply a wide variety of models in order to overcome the challenges posed by non-equidistant observations. The reasons why such unstructured time series are captured would be worth a study by itself, including the measurement techniques and corresponding strategic considerations that may improve the results.[1] Even though this unstructuredness can be described as an anomaly, we treat this phenomenon as a given, including the difficulties and challenges that are involved, and that today's analysts have to face.

In attempt to overcome these difficulties, a handful of techniques and approaches have been developed over time.

> *1*. In financial time series models (or even in meteorogical models addressing levels of precipitation), each gap between actual observations is usually filled with either zeros or with the value of the preceding observation.[2] Models, then, are based upon this "mended," augmented time series. This method, quite obviously, requires careful considerations as substitutions in large quantities can result in misleading conclusions.

[1] Three main categories can be differentiated within the group of unstructured time series, all of which are referred to as non-equidistant time series in this paper. These categories include structured but unequally spaced time series; structured time series with occasionally missing observations; and purely unstructured time series.

[2] Yield projection is one of the most frequent tasks in price modelling. In this case, replacing missing yields with zeros is equivalent to substituting the missing prices with the last preceding values (forward-flat interpolation).

2. Finding a frequency that matches every observation appears to be a more reasonable approach, as we can interpolate the observed values in order to substitute the missing values. The application of linear interpolations is undoubtedly a quick and convenient solution, although non-linearity tests often become less effective as they tend to indicate erroneously non-linearity (*Schmitz* [2000]).

3. A substantially more complex solution that this paper will not address in detail is creating an estimating function based on the covariance structure (autocovariance function) of the time series in order to fill in the missing values. In case a gap can be described with random variables having a probability distribution that is identical with that of the observed values, the Lomb-Scargle algorithm can be applied (see *Lomb* [1976] or *Schmitz* [2000]). This algorithm provides a periodogram of the missing values, and makes assumptions regarding gaps unnecessary.

4. The application of continuous-time models may be considered when the data series are genuinely unstructured. This issue has been addressed relatively early in modelling literature (see *Jones* [1985], *Bergstrom* [1985], or *Hansen–Sargent* [1991]). We also recommend the works of *Brockwell* [2001] or *Cochrane* [2012] who gave excellent summaries on this subject). For an exhaustive description of the state-space model based solution of parameter estimation, please refer to *Wang* [2013]. This model class is primarily designed for predictive purposes, however, the methods are based on the assumption that the time series, in fact, are equidistant, which can certainly be considered a weakness.

In this study, we focus on spline interpolation, a special class of interpolation methods. The focal issue being addressed is that the augmentation of gaps within non-equidistant time series (using averages, preceding values, etc.) often leads to incorrect and misleading conclusions as the augmented time series, after the augmentation, are treated as if they were, in fact, equidistant. Since the modelling techniques thereafter are based upon the assumption of equidistance, the original data generating function may have different characteristics than the ones that are implied based on the augmented time series. Another main purpose of this study is to illustrate that despite the fact that statistical software packages offer a variety of augmentation techniques "on a silver plate", they should not be routinely, "blindsightedly" applied.

After a brief overview of the most popular interpolation techniques, we are going to pay close attention to the basic features of spline interpolation. Following the section dedicated to this area, we address the risk of misspecifying data generating processes when the usual tests are run on augmented time series. To achieve this goal, we used computer-based simulations. In the final section of the paper, however, we use empirical non-equidistant time series in order to better portray our conclusions and recommendations.

1. Reassumption of missing values

The typical way of handling non-equidistant time series is by assuming that there is, in fact, an original equidistant time series from which certain values are missing. The most frequently used step, then, is the application of time series interpolation.[3] Here, we discuss two popular types of interpolation:

– the linear type (or log-linear, as the concept of the two are very similar) and
– the spline approach.

Both types of interpolation begin with the same step: we have to determine the frequency that best describes the time series in order to identify the locations of missing values to be augmented. In certain cases, this step doesn't require careful considerations, as a "natural" frequency may be trivial, even though not all expected observations are recorded (e.g. the gaps in daily stock market closing prices where the natural frequency is one per day and every sixth and seventh value is missing). In many other situations, however, there is no such trivial frequency: this is the case, for example, in time series compiled from world records in sports or when we consider the proportions of mandates representing the power of a government coalition, where the gaps between occurrences are not supposed to be equally spaced in the first place. Regarding the stock markets, national holidays across countries may cause similar problems and lead to unstructuredness.

The general recommendation is to derive the hypothetical frequency from the smallest gap between the actual observations. This, however, does not necessarily result in a frequency to which all actual values can be fitted. When it comes to determining hypothetical frequencies, the core dilemma is the following:

– On one hand, most or all original observations should match the theoretical (augmented) time series, which is an argument for assuming high hypothetical frequency.

[3] Note that interpolation is a generic term used in many contexts: its use is not limited to augmenting gaps in time series, but every estimation technique is referred to as interpolation when an ex post estimate is used between a pair of observations.

– On the other hand, the number of values obtained with interpolation should not exceed (or, according to some arguments, get close to) the number of actual values. This is an argument against assuming excessively high hypothetical frequencies.[4]

Once the hypothetical frequency is determined and the time series that still includes missing values is converted to equidistant sets, interpolation means the estimation of missing values between each pair of known empirical values.

The augmented time series obtained after the interpolation should have two main characteristics (prerequisites). Preferably, it should:

– not differ from the original values where empirical observations exist, and
– be relatively smooth.

Let the empirical time series be

$$y_{t_1}, y_{t_2}, \ldots, y_{t_k}, \ldots, y_{t_T}$$

where the distance $t_2 - t_1$ isn't necessarily equal to the $t_3 - t_2$ distance, etc. Let Δ denote the largest distance and let each $t_k - t_{k-1}$ be equal to or divisible by Δ.[5]

From this, the following, incomplete time series can be constructed:

$$y_{t_1}, y_{t_1+\Delta}, y_{t_1+2\Delta}, \ldots, y_{t_1+j\times\Delta}, \ldots, y_{t_T}$$

where $y_{t_1+j\times\Delta}$ are values to be determined by interpolation when a $t_1 + j\times\Delta$ does not match any of the empirical t_k observations.

Essentially, the purpose of interpolations is to give an estimation of values corresponding to points of time where no empirical observations were made or recorded. Linear interpolation is a simple method that does not completely fulfil our previous prerequisites. If

$$y_{t_{k-1}} = y_{t_1+(j-1)\times\Delta} < y_{t_1+j\times\Delta} < y_{t_k} = y_{t_1+(j+1)\times\Delta}$$

[4] In the last two decades, statistical literature has placed substantial emphasis on the fact that these criteria are difficult to meet in the case of ultra-high frequency data sets. For an overview of methodological tools and techniques that can be applied in similar situations (such as analyses based on stock market transactions), please refer to *Engle* [1996].

[5] This is often but not necessarily the same as the smallest distance between any two actual observations.

where $y_{t_1+j\times\Delta}$ are originally missing but both of their neighbours are known, the supplemental values can be obtained using

$$\hat{y}_{t_1+j\times\Delta} = y_{t_{k-1}} + \frac{y_{t_k} - y_{t_{k-1}}}{t_k - t_{k-1}} = y_{t_{k-1}} + \frac{y_{t_k} - y_{t_{k-1}}}{2\Delta}.$$

In case there are multiple missing values between two observations, interpolation can be performed by adjusting the denominator. In general, linear interpolation can be formalized as

$$\hat{y}^{LIN} = (1-\lambda)\, y_{t_{k-1}} + \lambda y_{t_k} \qquad /1/$$

where $y_{t_{k-1}}$ is the last non-missing value, y_{t_k} is the subsequent non-missing value, and λ denotes the relative position of the missing value between two known empirical values. (If there is one missing value, the known difference has to be divided by two; in the case of two missing values, the difference is to be divided by three, etc.)

Linear interpolation, however, tends to result in hectic, "fractured" diagrams, i.e. this method often leads to estimating functions with wildly oscillating slopes. To "tame" this phenomenon, we often turn to log-linear interpolation where estimated values can be generated using

$$\hat{y}^{LOGLIN} = e^{(1-\lambda)\ln y_{t_{k-1}} + \lambda \ln y_{t_k}}. \qquad /2/$$

Even though the logarithmic function leads to smoother diagrams, other problems arise, as negative values cannot be directly dealt with. Therefore, despite their simplicity, linear and log-linear interpolations are typically recommended as exploratory tools only.[6]

Spline interpolation, as well, has been developed with the purpose of obtaining smooth functions.[7] According to the original definition of this method, an $S(t)$ interpolating function is assigned to each section, each of which has to satisfy certain conditions. Using the same notations as earlier, where $t_1 < t_2 < \ldots < t_T$ are the points of observations and assuming that the corresponding values depend on time,

[6] These methods can be further improved by considering additional values besides the ones immediately before and after a given missing value, which can result in smoother functions. One of these methods is the cardinal spline method, a built-in tool included in the Eviews software package.

[7] For the first mathematical reference to splines, see *Schoenberg* [1946].

i.e. $y_{t_k} = f(t_k)$, the goal is to find an $S(t)$ function that fulfils the following criteria:[8]

$$S(t) = S_{t_k}(t) \quad t \in [t_1, t_T], \tag{C1}$$

$$S(t_k) = y_{t_k}, \tag{C2}$$

$$S_{t_k}(t_{k+1}) = S_{t_{k+1}}(t_{k+1}). \tag{C3}$$

These conditions, in a less formalized language, mean that interpolation can be performed piecewise, where each segment can be defined with a different function /C1/; the interpolating function's values match the original observations where they exist /C2/; and the curve that is obtained as a result of interpolation is continuous as interim observations are matched by connecting segments where both segments generate identical values /C3/. These three conditions are referred to as the general definition of spline interpolation.

The taxonomy of spline methods follows the type of the $S(t)$ functions.[9] Most often, these functions are polynomials chosen in a way that the derivatives (slopes) of the connecting segments are identical. Generally, a spline's degree and order are determined by the highest exponent of the polynomials in each segment (degree) and by the order of the two derivatives in the connecting segments (order).[10]

Here, we focus on two popular kinds of spline interpolation, in particular. These are:

– linear splines (discussed mostly for didactic reasons), and
– third degree, second order splines.

As for linear splines, let's focus on one interval first, and let this interval be $[t_{k-1}, t_k]$. Let us assume that the values at both ends of the interval are known. If the interpolated curve (stochastic process) between the two end points can be determined, then the missing values can be obtained from this very function.

[8] Here and hereinafter, criteria are abbreviated by "C".

[9] Even though the definition allows the use of different types of functions in each segment, generally the same class of interpolating functions is used in all intervals.

[10] The assumption that a process can be differentiated on a given interval is a serious restriction as it doesn't hold true for Brown motions. Therefore, it is important to emphasize that interpolation techniques are to be applied with caution.

By definition,

$$S_{t_{k-1}}\left(t_{k-1}\right)=\alpha_{t_{k-1}}+\beta_{t_{k-1}}t_{k-1}=y_{t_{k-1}},$$
$$S_{t_{k-1}}\left(t_k\right)=\alpha_{t_{k-1}}+\beta_{t_{k-1}}t_k=y_{t_k}$$

hold true for any spline. From this system of equations, the unknown parameters ($\alpha_{t_{k-1}}, \beta_{t_{k-1}}$) can be calculated, therefore, the spline can be determined.[11] The solution is identical with the linear estimation discussed earlier, i.e.

$$S^{LIN}(t)=y_t=y_{t_{k-1}}+\frac{y_{t_k}-y_{t_{k-1}}}{t_k-t_{k-1}}\left(t-t_{k-1}\right) \quad t\in\left[t_{k-1},t_k\right]. \qquad /3/$$

From this, it follows that the spline parameters can be different in each $\left[t_{k-1},t_k\right]$ interval.

In practice, typically third degree, second order spline interpolations are used, as their flexibility is coupled with a reasonable amount of calculations required.[12] In this case (cubic splines), three more conditions need to be added, extending /C1/–/C3/:[13]

$$S'_{t_{k-1}}\left(t_k\right)=S'_{t_k}\left(t_k\right), \qquad /C4/$$
$$S''_{t_{k-1}}\left(t_k\right)=S''_{t_k}\left(t_k\right), \qquad /C5/$$
$$S''\left(t_1\right)=0 \quad S''\left(t_T\right)=0. \qquad /C6/$$

In order to obtain the curves, those represent the interpolation, the parameters in

$$\begin{aligned}S^{CUB}(t)&=S_{t_{k-1}}\left(t_{k-1}\right)=y_{t_{k-1}}=\\&=\alpha_{t_{k-1}}+\beta_{t_{k-1}}\left(t-t_{k-1}\right)+\gamma_{t_{k-1}}\left(t-t_{k-1}\right)^2+\delta_{t_{k-1}}\left(t-t_{k-1}\right)^3 \quad t\in\left[t_{k-1},t_k\right]\end{aligned} \qquad /4/$$

[11] The system of equations can always be solved as by definition, $t_k-t_{k-1}>0$ holds true for the determinant of the coefficient matrix.

[12] Third degree, second order splines are typically referred to as cubic splines.

[13] This representation is valid for natural splines. It is not impossible that the second derivatives at the two endpoints are not equal to zero.

need to be determined, where $4(T-1)$ unknown parameters are paired up with the same number of conditions in /C2/–/C6/, which grants the feasibility of these calculations.[14]

The formerly described cubic spline interpolation is often replaced by CRS[15] in practical scenarios (*Catmull–Rom* [1974]). This method can be applied when non-equidistant time series are presumably equidistant by nature but include missing observations. Let us introduce the notation

$$y_{t_0 + j \times \Delta} = y_j$$

where y_0 is the first empirical value, y_1 is the second one, etc. The core idea, then, is to assume that all values (observed or missing) fit on a cubic polynomial of known values and derivatives:

$$y(t) = \alpha_0 + \alpha_1 t + \alpha_2 t^2 + \alpha_3 t^3 \ .$$

This, with respect to the first two points, means

$$\begin{aligned} y(0) &= \alpha_0 , \\ y(1) &= \alpha_0 + \alpha_1 + \alpha_2 + \alpha_3 \ , \\ y'(0) &= \alpha_1 , \\ y'(1) &= \alpha_1 + 2\alpha_2 + 3\alpha_3 \ . \end{aligned}$$

Let us solve the following system of equations for the unknown parameters:

$$\begin{aligned} \alpha_0 &= y(0) , \\ \alpha_1 &= y'(0) , \\ \alpha_2 &= 3\left[y(1) - y(0) \right] - 2y'(0) - y'(1) , \\ \alpha_3 &= 2\left[y(0) - y(1) \right] + y'(0) + y'(1) . \end{aligned}$$

[14] For proof, see *Mészáros* [2011]. The equal number of unknown parameters and conditions is necessary but not sufficient to solve the system of equations, as the non-singularity of the coefficient matrix is also required to obtain an existing and unique solution.

[15] CRS: Catmull-Rom spline.

Plugging the results back into the original polynomial and performing necessary simplifications, we arrive at the following third degree polynomial:

$$\begin{aligned} y(t) = & \left(1 - 3t^2 + 2t^3\right) y(0) + \left(3t^2 - 2t^3\right) y(1) + \\ & + \left(t - 2t^2 + t^3\right) y'(0) + \left(-t^2 + t^3\right) y'(1). \end{aligned} \qquad /5/$$

The difficulty of solving the equation in /5/ is caused by the fact that the derivative (slope) of the fitted curve is hard to determine. The fundamental concept of the CRS method is the assumption that these derivatives can be obtained based on the observed values. To find the spline on a $\left[y_j , y_{j+1} \right]$ interval, let us define the corresponding slopes as

$$y'(j) = \frac{y_{j+1} - y_{j-1}}{2} ,$$
$$y'(j+1) = \frac{y_{j+2} - y_j}{2} .$$

From this, the third degree polynomial can be rewritten in a matrix form:

$$y(t) = \begin{bmatrix} 1 & t & t^2 & t^3 \end{bmatrix} \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ -3 & 3 & -2 & -1 \\ 2 & -2 & 1 & 1 \end{bmatrix} \begin{bmatrix} y_j \\ y_{j+1} \\ \dfrac{y_{j+1} - y_{j-1}}{2} \\ \dfrac{y_{j+2} - y_j}{2} \end{bmatrix} .$$

After basic transformations, we obtain

$$y(t) = \begin{bmatrix} 1 & t & t^2 & t^3 \end{bmatrix} \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ -3 & 3 & -2 & -1 \\ 2 & -2 & 1 & 1 \end{bmatrix} \begin{bmatrix} 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ -\frac{1}{2} & 0 & \frac{1}{2} & 0 \\ 0 & -\frac{1}{2} & 0 & \frac{1}{2} \end{bmatrix} \begin{bmatrix} y_{j-1} \\ y_j \\ y_{j+1} \\ y_{j+2} \end{bmatrix},$$

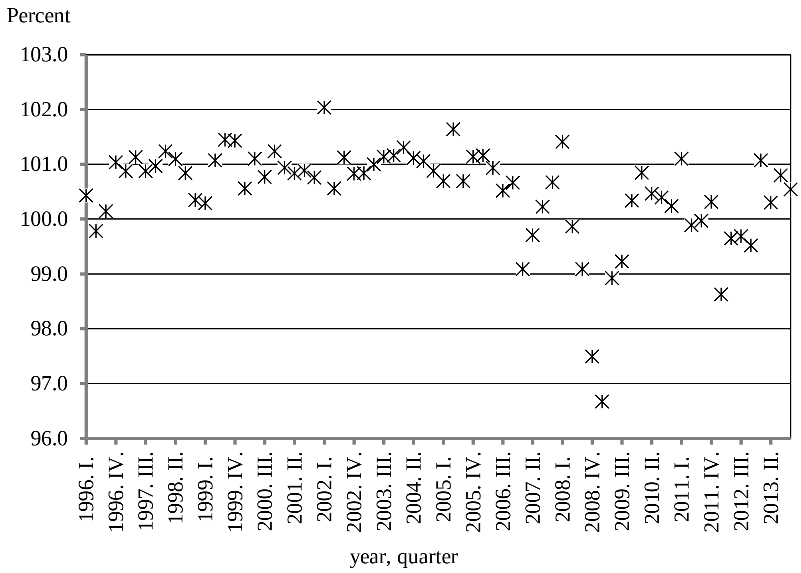
which can also be written as

$$y^{CRS}(t)=\frac{1}{2}\begin{bmatrix}1 & t & t^2 & t^3\end{bmatrix}\begin{bmatrix}0 & 2 & 0 & 0\\ -1 & 0 & 1 & 0\\ 2 & -5 & 4 & -1\\ -1 & 3 & -3 & 1\end{bmatrix}\begin{bmatrix}y_{j-1}\\ y_j\\ y_{j+1}\\ y_{j+2}\end{bmatrix}. \qquad /6/$$

The equation in /6/ is relatively easy to solve, and the results represent the time series between two chosen points. (From the equation, it also follows that the curves resulting from the interpolation can be different in each interval.)

Let us examine this through a simple example. Figure 1 represents the quarterly volume indices of the Hungarian real GDP[16] (quarterly changes) between 1996 and 2013.

Figure 1. Changes in the Hungarian real GDP, 1996–2013
(quarterly volume index)



Source: Hungarian Central Statistical Office (https://www.ksh.hu/docs/eng/xstadat/xstadat_infra/e_qpt008a.html).

In Figure 1, where each quarter is assigned to a value (our time series consists of 72 elements), trends are relatively hard to identify – hence the popularity of line charts.[17] By routinely connecting quarterly observations in such a fashion, we "in-

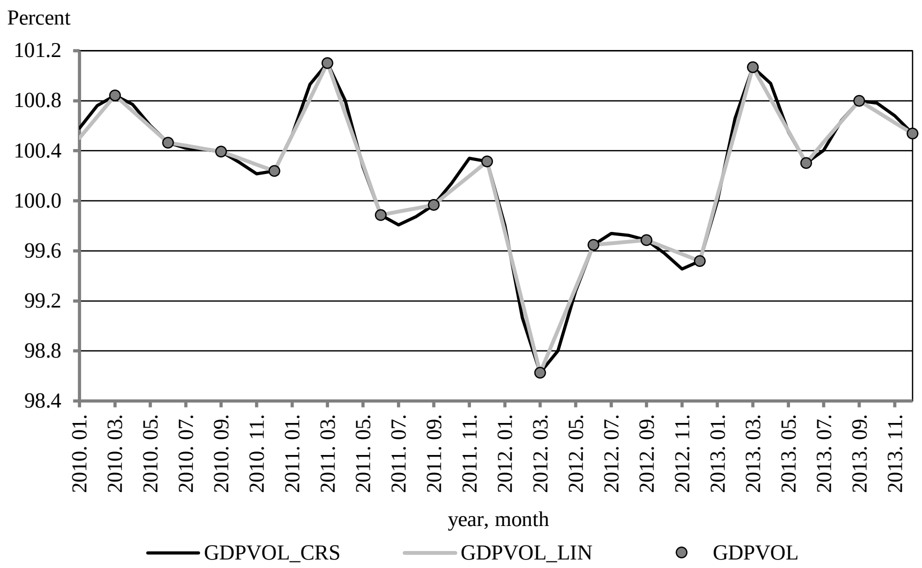
[16] GDP: gross domestic product.

[17] This is one of the reasons why line charts are more often used to represent time series, even if this is somewhat misleading. For rules and principles on visual representation, see *Hunyadi* [2002].

vent" some of the values between actual observations, often without being aware of having done so.

As mentioned earlier, interpolation can be performed in many ways. Figure 2 depicts estimated values by month where data points are broken down from quarterly information, using the linear and the CRS method.[18] In order to give a better visual representation, Figure 2 only includes the last four years' data, so that factual information (GDPVOL) and the values that were obtained from linear and CRS interpolation (GDPVOL_LIN, GDPVOL_CRS) are easier to tell apart.

Figure 2. Changes in the Hungarian real GDP, 2010–2013
(monthly values obtained from interpolated quarterly volume indices)



Source: Here and hereinafter, own calculation.

In certain points, the two interpolated time series in Figure 2 show noticeable differences, and generally, values that were obtained from polynomial splines tend to overshoot the values that were estimated with linear interpolation, especially where trends rebound, such as in mid-2011 or mid-2012. This is one of the reasons why the selection of interpolation techniques requires attention to detail and thoroughness.

[18] The Hungarian Central Statistical Office also provides a monthly breakdown of quarterly GDP values (not volume indices), following a methodologically different path, and therefore arriving at dissimilar numerical results.

2. Falsely identified process characteristics

In order to demonstrate the possible changes in the characteristics of data generating processes that may be induced by interpolation, we turned to simulations.[19] To maintain the comparability of the results, the constants (parameters) were chosen to be identical (or quasi-identical where full identity was not possible). Throughout the analyses, we followed the same principles:

1. For each predetermined model, we generated time series with lengths of 1 000.

2. From these time series, we randomly dropped 10, 20, ..., 90 percent of all "observations".

3. We augmented the resulting non-equidistant time series in two different ways: the missing values were either

– substituted with the expected values of the given process, or

– filled in using cubic interpolation.

4. Finally, based on 1 000 independent "experiments", we examined the differences between the characteristics of the original and the augmented time series for each of the two methods of replacement.

We examined three kinds of data generating processes, each of which are frequently used in empirical time series analysis. From these we generated the following three pairs of time series:

– determined by first order VAR[20] (1) models,
– including stochastic trends (random walk),
– being in perfect first order cointegration.

For all simulated time series, each value preceding the first empirical observation (y_0) was zero, and the random variables were chosen to be white noise processes (denoted by ε_t or by ε_{1t}, ε_{2t} when two processes were being handled concurrently).

The time series that have been generated from the VAR model were based on the model below and following the concept of the Granger test, in order to assess and analyse the unintended changes that may appear in the causal relationships between the time series

$$y_{1t} = 0.9y_{1,t-1} + 0.4y_{2,t-1} + \varepsilon_{1t}\ , \qquad y_{2t} = 0.9y_{2,t-1} - 0.4y_{1,t-1} + \varepsilon_{2t}\ .$$

[19] Simulations were run using EViews 8.1.
[20] VAR: vector-autoregressive.

This, in a matrix form, can be expressed as

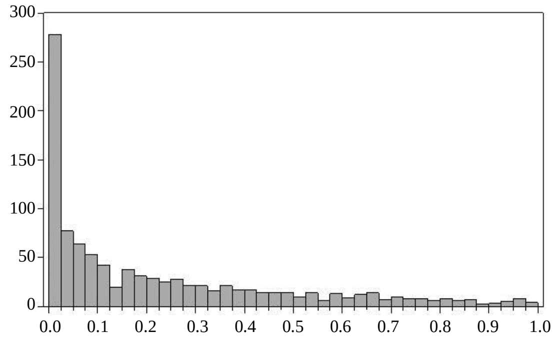
$$\begin{bmatrix} y_{1t} \\ y_{2t} \end{bmatrix} = \begin{bmatrix} 0.9 & 0.4 \\ -0.4 & 0.9 \end{bmatrix} \begin{bmatrix} y_{1,t-1} \\ y_{2,t-1} \end{bmatrix} + \begin{bmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \end{bmatrix}.$$

Based on common facts, processes that can be formalized using the VAR model are stationary if all eigenvalues of its coefficient matrix are inside the unit circle, and all non-diagonal elements of the parameter matrix are non-zero elements. As both conditions hold true in our example, Granger causality is present between the two variables. In our simulation, we investigated whether it is possible for the causality to disappear following the augmentation of non-equidistant time series.

Figures 3. *a*) and 3. *b*) represent the results of the simulations regarding the VAR models.

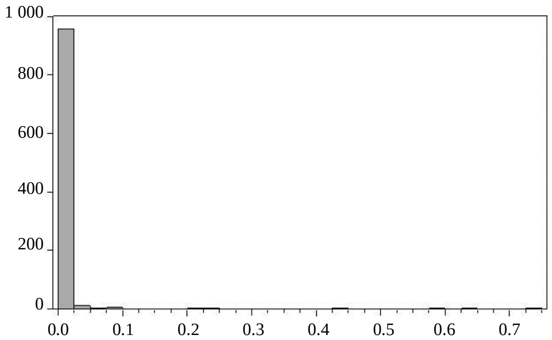
Figure 3. Levels of significance in Granger tests for causality between the variables obtained from the VAR data generating process

a) If missing values were replaced with their expected values



Mean:	0.223647
Median:	0.118050
Maximum:	0.990200
Minimum:	2.00e-11
Standard deviation:	0.253292
Skwness:	1.205539
Kurtosis:	3.484475
Jarque–Bera:	252,0005
Probability:	0.000000
Number of observations:	1 000

b) If missing values were replaced using spline interpolation



Mean:	0.009941
Median:	1.00e-10
Maximum:	0.738500
Minimum:	3.0e-202
Standard deviation:	0.064929
Skwness:	8.518263
Kurtosis:	80.81886
Jarque–Bera:	264417.4
Kurtosis:	0.000000
Number of observations:	1 000

Note. 90% of the original observations were missing.

Essentially, when missing values were replaced with averages, the Wald test determined causality (rejected the null hypothesis) in only 355 instances at $p = 0.05$. According to the same test at $p = 0.1$, decisions that matched the original data generating process only reached 472. Using spline interpolation, on the other hand, led to a higher number of correct decisions: according to the same test, the number of matching decisions reached 970 and 979 at $p = 0.05$ and $p = 0.1$, respectively, out of 1 000 instances. Based on this, we can conclude that the method of cubic spline interpolation is less likely to identify falsely the data generating process when the number of missing values is substantial.

As for the second type of data generating processes discussed herein, random walk plays a prominent role in time series analysis. Its significance, from our perspective, is due to two particular reasons. Firstly, its presence is the null hypothesis of the unit root tests, and secondly, its shifted version is the pure form of stochastic trends. Accordingly, we simulated two different types of random walk:

– random walk without drift

$$y_t = y_{t-1} + \varepsilon_t ,$$

– random walk with drift

$$y_t = 0.01 + y_{t-1} + \varepsilon_t .$$

Next, we examined whether it is possible to obtain a stationary unit root process if we remove some of its values and then “patch” the gaps using the augmentation techniques described earlier. To test the existence of unit roots, ADF[21] was used.

Regarding the third type of data generating processes discussed herein, we followed the specifications proposed by *Granger* [1988] in our simulations. The processes were:

$$y_{1t} = x_t + \varepsilon_{1t} ,$$
$$y_{2t} = 2x_t + \varepsilon_{2t}$$

where

$$x_t = x_{t-1} + \varepsilon_t .$$

Next, we examined the frequency of occurrences when theoretically cointegrated time series were determined as non-cointegrated, according to the Engle-Granger two-step method.

[21] ADF: augmented Dickey-Fuller test.

The main results of the simulations are summarized in Table 1.

Table 1

Falsely identified data generating processes
(count, out of 1000 simulated instances at $p = 0.05$)

Percent of missing observations	Type of augmentation	Process			
		VAR	RW ($\mu = 0$)	RW ($\mu = 0.01$)	ECM
10	Substitution	0	232	249	0
	Fill-in	0	57	52	0
20	Substitution	0	441	416	1
	Fill-in	0	47	48	0
30	Substitution	0	591	567	8
	Fill-in	0	52	56	0
40	Substitution	0	713	723	33
	Fill-in	0	36	60	0
50	Substitution	0	823	815	38
	Fill-in	0	65	57	0
60	Substitution	0	906	893	34
	Fill-in	0	67	70	0
70	Substitution	9	960	955	44
	Fill-in	0	79	43	0
80	Substitution	151	979	980	20
	Fill-in	1	73	67	0
90	Substitution	645	998	999	9
	Fill-in	30	123	105	1

Note. The term “fill-in”, in our table, means that missing values were replaced with their respective expected values. “Substitution” refers to augmentation using cubic spline interpolation. VAR stands for the vector-autoregressive model, RW denotes random walk, and ECM is the acronym denoting the cointegrated system, as it can be operationalized using the error correction mechanism.

The key observations and conclusions, based on the numerical results, are the following:

– Substitution may obscure Granger causality, especially at larger proportions of missing values. Our simulations support the conclusion that spline interpolation leads to better results than using expected values to replace missing observations.

– "Patching" non-equidistant random walk processes with expected values is an unequivocally erroneous choice. The misspecification of the original data generating process using spline interpolation, however, is unlikely, unless the proportion of missing values is substantial. (Note that the augmented Dickey-Fuller test itself results in 50 erroneous decisions out of 1 000 equidistant instances).

– In the case of cointegrated time series, spline interpolation led to fewer (close to zero) misspecifications. According to our analyses, spline interpolation is unquestionably the better alternative.

Based on our simulations, we can state that data augmentation with spline interpolation carries substantially less risk than traditional methods, given that the time series at hand are non-equidistant.

3. Illustrative examples

To understand better the technique of spline interpolation, let us examine two empirical examples.[22]

In our first example, let us take a closer look at the best times of two swimmers, *Daniel Gyurta* (Olympic and world champion, Hungary) and his rival, *Michael Jamieson* (Scotland), particularly their results in the 200-meter breaststroke. Our analysis encompasses the best times in a period of five years, during which 32 competitions were held where either of the swimmers were involved. During this time frame, there were only 7 occasions when both sportsmen participated. For an overview of the raw data set, please refer to Table 2. For a visual representation, see Figure 4.

As we can see, both swimmer's times are "generated" in a non-equidistant, random fashion.[23] Additionally, the dates of relevant competitions do not necessarily coincide, except when both athletes participate in the same meet.

[22] Please note that the results in this section are purely illustrative, and they are not intended to be used for professional decision-making purposes.

[23] The situation would be different if we considered the results of every competition and training, but this falls outside the main purpose of this paper. As our primary goal was to provide an illustrative example of the methods themselves, factors that may influence the swimmers' performance, such as life events etc., have been excluded from our analysis.

Table 2

Best times by meet, 2009–2013
(minutes:seconds.hundreths)

Date	Event	Gyurta	Jamieson
07/26/2009	World Cup	2:08.71	
04/03/2010	British Gas Championships		2:14.85
06/22/2010	British Gas Championships		2:13.63
08/09/2010	European Championships	2:08.95	2:12.73
01/15/2011	Flanders Swimming Cup	2:13.21	2:16.59
10/04/2010	British Commonwealth Games		2:10.97
02/11/2011	BUCS Long Course Championships		2:13.31
03/05/2011	British Gas Championships		2:10.42
03/25/2011	Budapest Open	2:12.67	
06/04/2011	Barcelona Mare Nostrum	2:12.48	2:12.83
06/08/2011	Di Canet Mare Nostrum		2:12.28
06/22/2011	Hungarian Championships	2:10.45	
06/30/2011	Scottish Gas National Open Championships		2:13.04
07/24/2011	World Cup	2:08.41	2:10.54
12/02/2011	Danish Open		2:10.40
01/13/2012	Victorian Age Championships		2:12.15
01/14/2012	Flanders Swimming Cup	2:11.79	
03/03/2012	British Gas Championships		2:09.84
03/29/2012	National Open Championship	2:12.65	
05/21/2012	European Aquatics Championships	2:08.60	2:12.58
06/02/2012	Mare Nostrum		2:11.21
06/13/2012	Budapest Open	2:09.89	
07/06/2012	6th EDF Open Championship		2:11.24
07/28/2012	London Olympics	2:07.28	2:07.43
01/19/2013	Flanders Speedo Cup	2:10.50	
02/08/2013	Derventio eXcel February Festival		2:11.75
03/07/2013	British Gas Swimming Championships		2:10.43
03/29/2013	Budapest Open	2:10.68	
06/13/2013	Sette Colli Trophy	2:10.25	
06/26/2013	Hungarian Championships	2:09.85	
06/28/2013	British Gas Championships		2:07.78
07/28/2013	World Cup	2:07.23	2:09.14

Source: http://bit.ly/1ECuw3N, the official website of the International Swimmers' Alliance. Only best times per meet are considered.

Figure 4. Best times of Gyurta and Jamieson

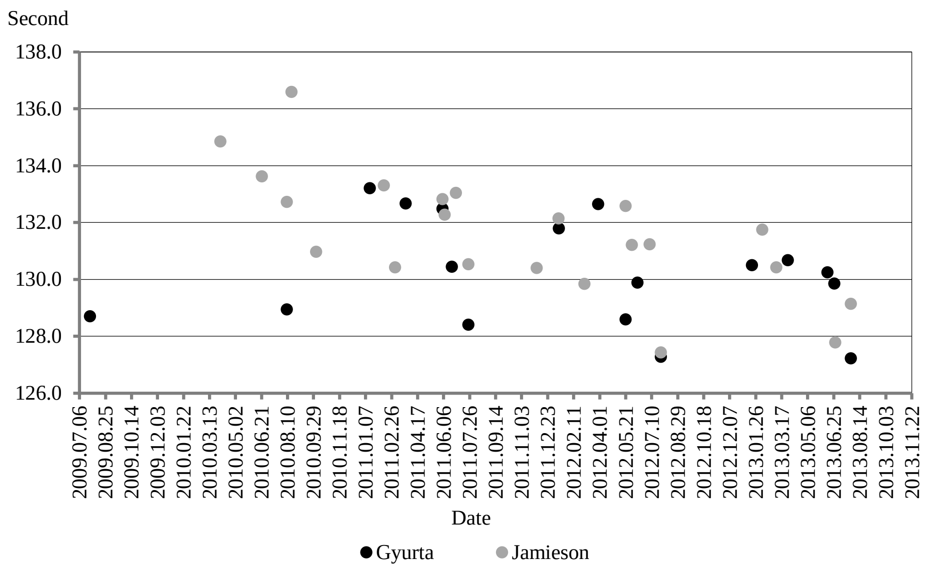


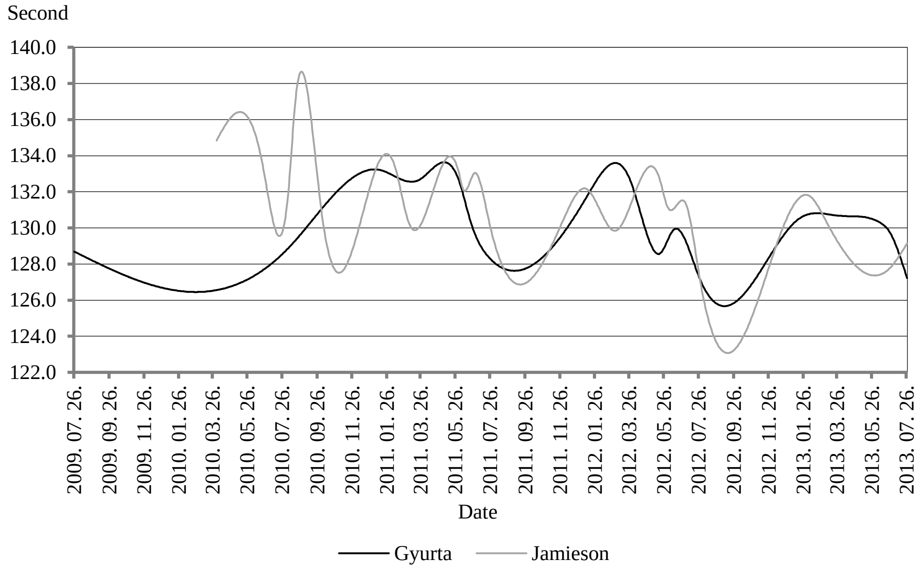
Figure 4 is not overly informative: best times are difficult to identify and comparisons are challenging to make. Even though individual results are obviously easy to compare (e.g. Gyurta beat his rival during the London Olympic Games or at the 2013 World Championship; lesser times are better), but a similar comparison is more difficult to make with respect to the entire time horizon involved in our analysis.

Interpolation, as it provides us with certain values in-between actual observations is one way to make such comparisons possible.[24] Our primary goal, now, is to illustrate the theoretical possibility of estimating changes in performance using interpolation when empirical values are assigned to unequally spaced events. As the dates of competitions were not equally spaced, i.e. the assumption that the time series is equidistant with certain missing observations does not hold true, the application of cubic splines appears to be a reasonable response.[25] For a visual representation of the results, see Figure 5.

[24] Again, it is not our goal to discuss whether the results are actually comparable from a sports professional's point of view (e.g. whether having a competition before, during or after a training camp affects performance, etc.).

[25] This does not imply that competitions are held on a specific day in each month with or without the participation of either Gyurta and/or Jamieson, but it refers to the fact that there are specific sports seasons in each year with longer periods of off-season intervals in-between.

Figure 5. Best times of Gyurta and Jamieson
(estimated values using spline interpolation)



One does not have to be well versed in swimming to realize that the "fictional" values generated by interpolation are not necessarily realistic. Based on this figure, one may come to the conclusion that even though the Scottish athlete has lost the Olympic Finals, his performance has gone through such an improvement during the Olympic Games that he would have been able to achieve significantly better results shortly afterwards, and possibly even set a new world record. Then, following 2012, his performance started to decay again, and despite a rapidly passing improvement, he already got past his top shape before the world championships began. Gyurta, on the other hand, appears to be the athlete with more stable (less unpredictable) numbers whose performance peaks at the most important meets, each year. If we catch ourselves automatically accepting such conclusions as a kind of model verification, we have to remind ourselves repeatedly that spline interpolation is a tool to be handled carefully.

Let us now look at another example that we have referred to earlier in this study. According to the market model (see *Bélyácz* [2009], p. 77.), the yields of a specific stock (or any investment) can be written as

$$r_i = \alpha + \beta r_M$$

where r_i is the yield of the investment i, r_M is the yield of the market portfolio, and α and β are model parameters that are to be estimated. In this model, the latter parameter has a more significant role as it is often used as a proxy, measuring the individual risk of a given investment.

In the specific parameter estimation process, the yield of an individual investment (stock) at time *t* is calculated using

$$r_{it} = \frac{p_{it} - p_{i,t-1}}{p_{i,t-1}} \approx \Delta \log p_{it}$$

where p_{it} denotes the closing price of the given stock on day *t*.

Similarly, market portfolio yields can be estimated using the closing prices of the stock market index (in our example, the BUX[26]). Therefore, we can populate the time series for both variables that are required in our model (market and individual investment yields). Since yields typically form stationary time series, OLS[27] parameter estimation is considered an efficient method.[28]

From our point of view, the fact that daily closing prices are only seemingly equidistant (the values from weekends and holidays are, in fact, missing) is of high importance. In practice, β estimation is often performed after the missing values are replaced with the previous days' closing prices, i.e. yields on such days are made equal to zero. This, however, involves the risk that otherwise existing causal relationships between variables may disappear.

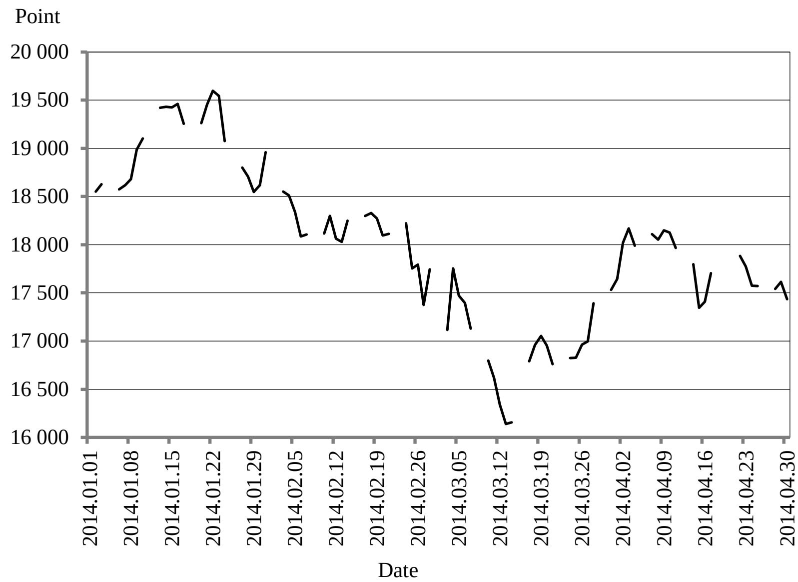
Let us now consider the first four months of 2014, and examine the difference of the results between the two approaches of time series augmentation (fill-in versus substitution). In this example, we are looking at the estimated β values of the blue chips traded on the Budapest Stock Exchange. For a visual representation of the BUX closing prices within the given period, see Figure 6.

[26] BUX: Budapest Stock Index.

[27] OLS: ordinary least squares.

[28] In a previous study (*Varga–Rappai* [2002]), we have shown that parameter estimation leads to more sound results using GARCH (generalized autoregressive conditional heteroscedastic) specifications. This, however, exceeds the focus of this paper.

Figure 6. Closing prices of the BUX in the first four months of 2014



The gaps in Figure 6 represent weekends, holidays and other occasions when trading is suspended. We would obtain similar gaps by depicting the closing prices or daily yields of the aforementioned blue chips, specifically the stock prices of the following companies: MOL, MTELEKOM, OTP, and RICHTER.

We estimated β, the coefficient describing individual investment risk, in three different ways.

– Only considering days of active trading, i.e. with the assumption that yields between Fridays and Mondays are generated the same way as they are between Mondays and Tuesdays. This scenario resulted in 83 individual data points.

– In our second approach, every day within the four-month period was assigned a daily yield, in a way that weekends and holidays generated zero yields, and other values were obtained from actual yields (from the differences between closing prices). This method resulted in a time series consisting of 120 data points for each blue chip.

– Finally, we used cubic spline interpolation in order to eliminate gaps, from which four time series (one for each stock) of 118 data points were obtained, as the first two days of the year had no preceding values.

For a summary of results, see Table 3.

Table 3

Estimated β values by method of augmentation

Blue chip	Approach (length of time series)		
	Weekdays only (T = 83)	0 yield on weekends (T = 120)	Augmented time series using spline interpolation (T = 118)
MOL	0.9109	0.9176	0.9040
MTELEKOM	0.4704	0.4695	0.5017
OTP	1.2715	1.2658	1.6214
RICHTER	1.0825	1.0771	1.2744

The results speak for themselves. On the one hand, replacing missing yields with zeros leads to estimated coefficients that barely differ from estimates, which were obtained by ignoring the existence of weekends and holidays, i.e. by ignoring the effect and role of time at which yields were generated. On the other hand, if we consider the estimated β coefficients that were obtained using spline interpolation, especially the ones that indicate a higher level of risk ($\beta > 1$), we can observe that these estimates are noticeably different from the values that were calculated using either of the first two methods. This implies that changes following weekends and other holidays should be paid special attention. In other words, an additional amount of risk should be associated with individual investments that tend to diverge from the direction of the market as a whole if this divergence is particularly noticeable after weekends and other holidays.

4. Conclusions

One of the most prevalent characteristics of today's information society is the enormous amounts of data that researchers and analysts have to face. Whereas having bigger data sets and longer time series can be beneficial from a certain point of view, one should not forget about the downside of such tremendous amounts of information: the decline in its quality. Data quality is a rather complex category – in this study, the phrase is not used in a way it is defined by statistical terminology, but it is interpreted from the analyst's point of view. From the same perspective, a significant drawback of large data sets and long time series is volatility (statistically speaking, variance or standard deviation). Besides this phenomenon, other difficulties need to be addressed, such as the appearance of outliers and structural frictions. Many of these phenomena became typical in today's information society, one of which has been addressed herein. One of the main reasons why non-equidistant time series have become more common these days is that analysts now typically rely on multiple data providers, as opposed to the past when a single provider was deemed unquestionable and therefore reliable.

The core dilemma that today's analysts have to face when dealing with such time series is whether they should exclude certain observations in order to qualify them for more traditional modelling techniques by inevitably losing otherwise available information, or if their models should be based on most or all of the available data, taking their unstructured nature, in some way, into account. Since inappropriate choices of data augmentation techniques may affect the basic characteristics of a non-equidistant time series, we have placed significant emphasis on selecting the most desirable methods in our analyses.

The spline interpolation methods discussed herein are relatively straightforward and are supported by the vast majority of standard software packages. Therefore, their use can be recommended to analysts who wish to avoid losing empirical data but also strive to retain the characteristics of the original time series. However, as data augmentation results in conclusions that are not solely based upon original data, time series augmentation should be used with caution. The extent to which analysts should rely on non-empirical data is an ethical question far exceeding the purpose of this study.

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Examination of Pharmaceutical Innovation Diffusion Using the Cox Model*

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The article aims at identifying micro- and meso-level characteristics of the early prescribers of newly marketed innovative drugs. The diffusion of the two most popular, new blood glucose lowering oral antidiabetic drugs (Eucreas and Janumet) is assessed. The process of diffusion is complex – although doctors consider each new drug on its individual merits, some seem more predisposed to adopt them than others do. Therefore, understanding the mechanisms leading to early adoption of new drugs is highly relevant for speeding up the spread of medical innovations, promoting cost-effective prescriptions, developing targeted detailing, and predicting the utilization of new medications. Cox's proportional hazard model is used to examine factors influencing the likelihood of specialists' initial adoption. Belonging to one of the classes of survival models in statistics, the Cox model relates the time passing until new drug uptake to four significant covariates for both Eucreas and Janumet. For these medications the portfolio width of a specialist and the proportion of patients treated with insulin are significant determinants of new drug prescribing. In contrast, working for an academic medical centre and being in a high position do not increase the likelihood of adoption. The authors' results are in line with the findings of similar empirical studies.

KEYWORDS:
Cox model.
New drugs diffusion.

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Innovation and the successful diffusion of new drugs are critical for the financial performance of pharmaceutical companies as well as the health of patients. At macro level, governments are also major influencers, both through regulatory and approval agencies and through budgetary allocations. The diffusion of innovation is thus determined by the strategies of pharmaceutical companies, government policies as well as the behaviour of medical professionals. This article concentrates on the last, through investigating the determinants of prescribing new drugs by specialists.

Understanding the mechanisms leading to prescribers' early adoption of new drugs is important for several reasons (*Lublóy* [2014]). First, it *accelerates diffusion*. Although companies are increasingly innovative and efficient in producing new drugs, the implementation of pharmaceutical innovations is often delayed (*Berwick* [2003]). Where new drugs expand therapeutics in areas of yet unmet clinical need, accelerated adoption benefits both medicine and society, through fast and homogeneous availability. Second, it *promotes cost-efficiency*. Healthcare systems worldwide operate with limited financial resources. When the same pharmacological therapy is available as different brands at different prices, prescribers need to select the new, more expensive brand on medical grounds rather than socioeconomic considerations such as wealthy or demanding patients (for example, *Ohlsson–Chaix–Merlo* [2009]). Third, it *forecasts utilization*. Accurate prediction is important not only for pharmaceutical companies but also for healthcare professionals and policy makers in charge of healthcare budget planning. Fourth, it *develops targeted detailing and continuing medical education*. Distinguishing between doctors who prescribe new drugs early and those who prescribe them late or never enables targeted pharmaceutical company intervention, through relevant, tailored information; economies of both time and money; and appropriate use of new drugs, through prescription of the most efficient/least expensive alternatives.

Doctors have to strike a balance between using new drugs, potentially exposing patients to side effects, and delaying their use, depriving patients of possible benefits. The ensuing diffusion process is complex – although doctors consider new drugs on individual merits, some may be more predisposed to adopt than others do. Several factors are significantly positively associated with early adoption of new drugs (*Lublóy* [2014]): *1.* physicians' interest in particular therapeutic areas, participation in clinical trials, and prescribing volume, either in total or within the therapeutic class of the new drug (for example, *Coleman–Katz–Menzel* [1966], *Glass–Rosenthal* [2004], *Lin–Jan–Kao* [2011], *Liu–Gupta* [2012]); *2.* pharmaceutical companies' marketing efforts (for example, *Kremer et al.* [2008], *Manchanda–Xie–Youn* [2008], *Iyengar–Van Den Bulte–Valente* [2011], *Liu–Gupta* [2012]); *3*. social interactions among colleagues, with pharmaceutical sales representatives, and with patients (for example, *Coleman–Katz–Menzel* [1966], *Manchanda–Xie–Youn* [2008], *Iyengar–Van Den Bulte–Valente* [2011], *Lin–Jan–Kao* [2011], *Liu–Gupta* [2012]) – colleagues are indispensable to gaining knowledge and reducing uncertainty about the consequences of new drug adoption (*Peay–Peay* [1994], *McGettigan et al.* [2001], *Prosser–Walley* [2006]); and *4*. physicians with younger patients, patients with higher socioeconomic statuses, and/or patients with poorer health statuses (for example, *Mark et al.* [2002], *Greving et al.* [2006], *Ohlsson–Chaix–Merlo* [2009], *Liu–Kao–Hsieh* [2011]). Some *5*. socio-demographic and *6*. practice-related factors also play important – albeit lesser – roles in the diffusion process.

This article focuses on the diffusion process of new A10Bs[1] for the treatment of T2DM[2]. Pharmaceutical companies are keen to develop such drugs, due to the increasingly high potential market – 347 million people suffer from diabetes worldwide (*Danaei et al.* [2011]), projected to become the seventh cause of death in 2030 (*WHO* [2011]). In Hungary alone, 11 brands were introduced in a subsidized form between April 2008 and April 2010.

In particular, this article assesses the diffusion process of the two most popular, recently introduced, oral anti-diabetic drugs. The Novartis brought Eucreas, having the active substances of metformin and vildaglipin, in November 2008 onto the market. Shortly after introduction, it became the market leader among the new anti-diabetic drugs. Merck Sharp & Dohme launched Janumet, having the active substances of metformin and sitaglipin, in February 2009. As of December 2011 Janumet was the second most successful, newly introduced anti-diabetic drug.

The determinants of new drug diffusion can be best captured by survival models, which examine the factors influencing the time that passes until new drug uptake. Semi-parametric survival models offer substantial advantages over parametric and non-parametric models. A well-known example of a semiparametric survival model is the *Cox* proportional hazard model [1972] that is used in this article as well.

Our study is structured as follows. After introduction, Section 1 describes the survival models briefly, special attention is paid to the Cox's proportional hazard model. Section 2 presents the key characteristics of the studied drugs, the specialists adopting the new oral antidiabetics, and specifies the dependent variables. Section 3 presents the Cox model results (four significant covariates for both studied drugs). Section 4 discusses the results alongside with policy implications. It lists several possible research limitations and suggests directions for future research as well.

[1] A10B: anti-diabetic drug. The World Health Organization' Anatomical Therapeutic Chemical (ATC) classification for blood glucose (HbAc1) lowering drugs other than insulin, based on the organs/systems on which drugs act and/or the therapeutic and chemical characteristics of the drugs.

[2] T2DM: type 2 diabetes mellitus.

1. Survival analysis and Cox's proportional hazard model

Survival analysis is a branch of statistics that deals with the assessment of time duration until one or more particular events happen. It is predominantly applied to irreversible events. For example, once a specialist wrote a prescription for a newly introduced drug, he/she might not be considered as a non-adopter. Survival models might be classified into non-parametric, parametric, and semi-parametric approaches.

Non-parametric survival models focus on the shape of the distribution of the survival times. The most important advantage of non-parametric analysis is that the results do not depend upon distributional assumptions; it lets the data speak for themselves. The non-parametric techniques eventuate in survival and hazard functions that are easy to interpret. In general, they can compare the distribution of the survival times for various patient cohorts or medical therapies. Among them, the *Kaplan–Meier* estimator [1958], also known as the product limit estimator, is the most widely used method for estimating the survival function. The major disadvantage of the non-parametric techniques is that they can only compare a limited number of groups. As a result, it is very difficult to assess the impact of one explanatory variable while controlling for other variables. Additional disadvantages include that they can only deal with qualitative explanatory variables and do not provide a numerical estimate for the relationship between the covariates and the survival time.

Parametric techniques make assumptions both about the functional form of the probability distribution and the way that the covariates influence the survival time. Similarly to regression analyses, for each covariate a coefficient is derived. The most commonly used probability distributions are the exponential, the Weibull, the Gomperz and the lognormal distributions. The main disadvantage of the parametric analysis is that the estimates are influenced by the assumptions about the shape of the survival and hazard functions. There is an intermediate technique whereby only the assumption about the way that the covariates influence the survival time is made – it is called as semi-parametric approach and particularly popular in survival analysis.

Cox's proportional hazard model [1972] is the most widely used semi-parametric survival model. The Cox regression analysis yields an equation for the hazard as a function of several explanatory variables. By definition, the hazard function is the probability that an individual will experience an event (e.g. adoption) within a small time interval given that the individual has survived up to the beginning of the interval. It can therefore be interpreted as the risk of an event occurring at time *t*. In Cox regression, the explanatory variables are named as covariates. The model can easily handle covariates that are categorical or continuous. Furthermore, the covariates might be time invariant or time varying during observation.

The Cox regression estimates the hazard ratios, exp(β)s; the values of the respective variables differ by one unit, all other covariates are being held constant. Variables with exp(β)s larger than one are associated with increased hazard – the higher the variable, the higher the hazard of the event (*Fox* [2002]).

The Cox model does not require the choice of some particular probability model to represent survival times, and is therefore more robust than parametric methods. Additional advantages of the Cox regression include modelling the effect of covariates on the hazard rate but leaving the baseline hazard rate unspecified. Furthermore, it handles right-censored data appropriately. Right censoring typically occurs when information on time to event is unavailable due to non-occurrence of outcome event before the end of the observation period. In this article, specialists are thus censored in cases where they had not routinely adopted the A10Bs by the end of 2011 (time *t*) (*Garson* [2013], *Klein–Moeschberger* [2005]).

Similarly to many recent diffusion studies (e.g. *Korda–Clements–Dixon* [2011], *Lin–Jan–Kao* [2011]), the present article employs the semi-parametric Cox regression with right-censored data as specified in Equation /1/. The dependent variable is a dummy indicating each month whether the specialist had routinely adopted the newly introduced drug.

$$h(t,\mathbf{x}) = h_0(t,\alpha)\exp\left(\boldsymbol{\beta}^{\mathbf{T}}\mathbf{x}\right) \qquad /1/$$

where $h_0(t,\alpha)$, is the baseline hazard function, *t* is the time, α is a parameter influencing the baseline value, exp(**β**) is the vector of hazard ratios, and **x** is the vector of the explanatory variables. In Cox's proportional hazard model $h_0(t,\alpha)$ is dependent upon time, but independent of the explanatory variables, whereas $\exp\left(\boldsymbol{\beta}^{\mathbf{T}}\mathbf{x}\right)$ is independent of time, but dependent upon the explanatory variables.

In this article, statistical calculations are performed using SPSS (version 22.0). The covariates are entered into the Cox model in one single step, without checking their significance (forced entry, default option in SPSS). The covariates are time invariant. For multiple highly correlated covariates (with coefficients higher than 0.85), only one variable from the set of intercorrelated variables is used. For testing the overall fit of the Cox model, an omnibus test is performed (*Fox* [2002]). If the null hypothesis is rejected, then the suggested Cox model is not significantly suitable to the data.

2. Data

The main database is managed by DoktorInfo Ltd. and covers prescription information between April 2008 and December 2011. All general practitioners in Hungary are required by law to collect data for NHIFH[3]. Of these, 899 (22%) also feed real-time prescription data into the DoktorInfo database voluntarily. This involves no additional work for general practitioners, who are compensated for providing information such as general practitioner identification number, prescription date, prescribed drug characteristics (brand name, ATC code, and dosage), prescribed drug subsidy, and patient characteristics (age and gender).

2.1. Doctors and drugs

The Doktorinfo database is representative of the entire Hungarian general practitioner population in both age and location (defined by region and population size). Since January 2009, for patients whose care is shared, the identification number of the therapy-initiating specialist is published on the prescription as well. This information enables monitoring the adoption behaviours and prescribing patterns of specialists who share care of T2DM patients.

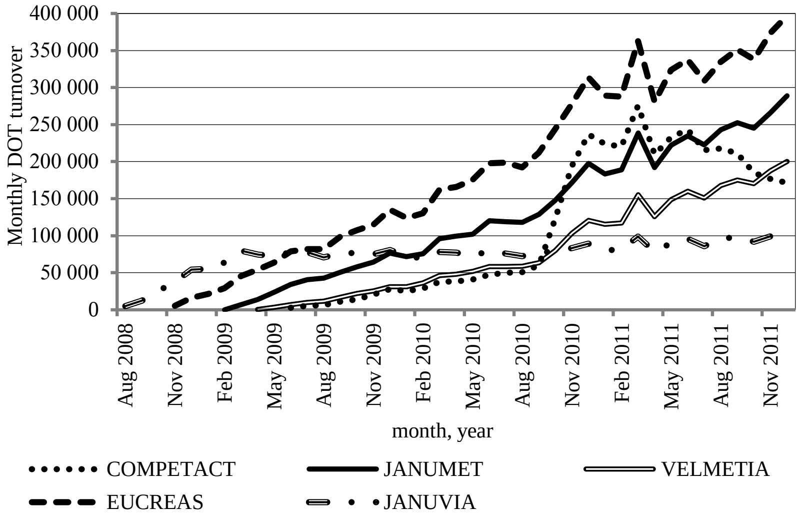
The 318 physicians analysed here account for roughly 80% of the specialists who treated patients with T2DM on a daily basis. It is important to emphasize that not all prescriptions written by specialists are taken into account, only those prescriptions are included in the Doktorinfo database which were initiated by specialists within the shared care scheme. We examine routine, as opposed to just first-time adoption of new A10Bs. Adoption becomes routine when specialists first ask referring general practitioners to prescribe new A10Bs, on grounds of efficacy and efficiency. Intuitively, any such drugs are already part of the specialists' prescribing portfolios, following first-time adoption and follow-up tests. From the 11 recently introduced antidiabetic drugs, the diffusion process of Eucreas and Janumet is analysed in this article in detail.

Figure 1 shows the brand sales of the five most successful, new oral antidiabetic drugs expressed as the number of DOT[4] between January 2008 and December 2011. Novartis introduced Eucreas to the Hungarian market in November 2008. In less than a year it became the market leader among the newly introduced anti-diabetic drugs; this position was hold until the end of the observation period. The daily cost of treatment with Eucreas is HUF 416 – thus it might be considered as a middle-priced first-in class drug (*NHIFH* [2013a]).

[3] NHIFH: National Health Insurance Fund of Hungary.
[4] DOT: days of treatment.

Merck Sharp & Dohme introduced Janumet to the Hungarian market in February 2009. Although its sales have been steadily increasing since then, Janumet never became the market leader. Since July 2011, it has been the second most successful, newly introduced oral anti-diabetic medication. On the day of the rollout, the daily cost of treatment with Janumet was HUF 397 – it is the second cheapest first-in class antidiabetic medication (*NHIFH* [2013a]).

Figure 1. Monthly DOT turnover of the five most successful, newly introduced antidiabetic drugs



Source: Own calculation based on *NHIFH* [2013b].

2.2. Dependent variable

This article has identified 19 determinants that may affect specialists' routine prescribing of new A10Bs. The determinants are grouped into five categories of factors: specialists' socio-demography, workplace, practice, prescribing and patient characteristics.

The another database used in this article is managed by the Office of Health Authorization and Administrative Procedures (*HRTC* [2013]) and covers socio-demographic and practice-related variables as well as physician characteristics.

Socio-demographic characteristics include gender, age of the specialist and number of specialties. The average age of specialists in the sample was 52, the youngest specialist was 32 years old, the oldest one was 78 years old, and 152 specialists (47.8%) were male. On average, specialists had 1.78 specialties.

Workplace characteristics contain the number of workplaces, the position of the specialist, and the type of the institution where the specialist's practice is embedded. On average, specialists worked in 1.46 practices. The position of the specialists was divided into three categories: *1*. high position ((deputy) head of hospital department or outpatient centre); *2*. medium position (chief physician); *3*. low position (associate professor or physician). The institutions where the specialists practice were divided into four groups: *1*. clinic; *2*. university/teaching hospital; *3*. hospital; *4*. outpatient centre and other.

Table 1 summarizes the descriptive statistics of the specialists' socio-demographic and workplace characteristics.

Table 1

Socio-demographic and workplace characteristics of specialists

Variable	Average	Minimum	Maximum	Standard deviation
Gender of the specialist (0 – male; 1 – female)	0.48	0.00	1.00	–
Average age of the specialist (years)	51.92	32.00	78.00	9.94
Number of specialties	1.78	1.00	4.00	0.78
Number of workplaces	1.46	0.00	5.00	0.69
Position of the specialist (1 – head or deputy; 2 – chief physician; 3 – associate professor or physician)	–	1.00	3.00	–
Institution type (1 – clinic; 2 – university/teaching hospital; 3 – hospital; 4 – outpatient centre and other)	–	1.00	4.00	–

Source: Own calculation as of December 2011.

In addition to the socio-demographic and workplace data, information on the specialists' practice, prescribing habits and patient portfolio were collected as well.

Practice characteristics include the number of the specialist's T2DM patients whose care is shared with general practitioners; mean number of consultations per patient resulting in confirmation or change of therapy suggested by the specialist; size of city where the specialist works, proxied by number of inhabitants; prescribing volume; prescribing intensity (mean number of prescriptions per patient); proportion of loyal patients (patients consulting each time the same specialist); number of referring general practitioners (number of general practitioners with whom the specialist share patient care). Table 2 shows the descriptive statistics of specialists' practice characteristics.

Table 2

Practice characteristics of specialists

Variable	Average	Minimum	Maximum	Standard deviation
Number of patients	123.48	14.00	784.00	114.71
Mean number of consultations per patient	1.68	1.00	2.85	0.37
Practice location (1 – Budapest; 2 – large city; 3 – medium-sized city; 4 – small city)	–	1.00	4.00	–
Prescribing volume	1 569.59	315.00	12 262.00	1 618.11
Prescribing intensity (mean number of prescriptions per patient)	12.71	4.63	30.93	3.72
Proportion of loyal patients (%)	70.77	17.54	100.00	19.76
Number of referring general practitioners	21.56	1.00	84.00	15.95

Source: Here and in Tables 3 and 4, own calculation based on data from January 2010 to December 2011.

On average, a typical specialist suggested therapies for 123.48 patients and saw patients 1.68 times. The number of consultations per patient shown in Table 2 is a lower estimate – due to data limitations only those consultations were taken into account that resulted in new prescription initiations by specialists. In shared care systems, specialists hold the exclusive right to start therapies with specialist medications. When specialists initiate certain therapies, general practitioners have to prescribe that medication for a time, usually for one year. To obtain prescribed medication, patients have to visit their general practitioners monthly. Prior research suggests that practice location – rural vs. urban, central vs. peripheral – might also influence new drug uptake (*Lublóy* [2014]). Practice location was categorized by the size of the settlement in which the specialists have their main practices. Using data from *HCSO* [2011], settlements were grouped into four categories: *1*. Budapest; *2*. large city (100 thousands–1 million inhabitants); *3*. medium-sized city (40–100 thousands inhabitants); *4*. small city (under 40 thousands inhabitants). Specialists asked general practitioners to write 1 570 prescriptions – 12.71 prescriptions per patient. Over two thirds of patients (23 671, 70.77%) were loyal to their specialists and did not consult other specialists in the sample. The proportion of loyal patients, variable never assessed in the literature before, might influence new drug uptake as well – presumably specialists are more inclined to prescribe new drugs to patients whom medical history they know better. A typical specialist received referrals from 21.56 general practitioners.

Prescribing characteristics include portfolio width (number of brands prescribed for patients in shared care) and ratio for old A10B (prescriptions for previously introduced A10Bs). Specialists prescribed 4-25 brands to their patients with diabetes.

A typical specialist prescribed almost 17 brands within the therapeutic class. (See Table 3.) The ratio of prescriptions for old oral anti-diabetic drugs might refer to the specialists' general conviction of the proper therapy for diabetes – a therapy being debated in the literature (*Krentz–Bailey* [2005], *Scheen* [2005], *Davis–Abraham* [2011]). The mean ratio of prescriptions for old oral anti-diabetic medications was less than 3%. As a maximum, 33.33% of the prescriptions were for old oral anti-diabetic medications.

Table 3

Prescribing characteristics of specialists

Variable	Average	Minimum	Maximum	Standard deviation
Portfolio width (number of prescriptions)	16.66	4.00	25.00	4.13
Ratio for old oral antidiabetic medication (%)	2.99	0.00	33.33	4.66

Patient characteristics include the mean age of patients, proportion of male patients and mean annual income of patients in the specialist's patient panel and the ratio for insulin (proportion of prescriptions for insulin). The respective descriptive statistics are shown in Table 4.

Table 4

Patient characteristics

Variable	Average	Minimum	Maximum	Standard deviation
Mean age of patients (years)	64.20	44.00	72.87	2.84
Proportion of male patients (%)	47.07	7.02	70.37	7.39
Ratio for insulin (%)	79.10	0.00	100.00	20.84
Mean annual income of patients (thousand HUF)	930.98	380.06	1511.87	179.24

A typical specialist's patient panel was composed of patients with a mean age of 64 years. Forty seven percent of the patients were male. The ratio of prescriptions for insulin might refer to the severity of diabetes. In general, patients are treated with insulin if oral anti-diabetic medications failed. The mean ratio of prescriptions for insulin was 79.1%. The large standard deviation of this ratio reveals large differences in the prescribing habits among specialists. Prior research suggests that high-income patients receive new drugs earlier than others do, not least because of their ability to pay for out-of-pocket treatments (*Lublóy* [2014]). Moreover, expert interviews suggest that in Hungary low-income patients are treated rather with insulin as it is covered by 100% state subsidy. Patient income, that is, the average income of the inhabitants living nearby the general practitioner's office was proxied by either the mean street-level income (settlements over 20 thousand inhabitants) or by the zip code level income (small settlements) based on the zip code/street of the patients' general practitioner office, using the database of *GEOX* [2013]. The average annual income of patients was around HUF 930 thousand, approximately EUR 3100.

2.3. Correlation

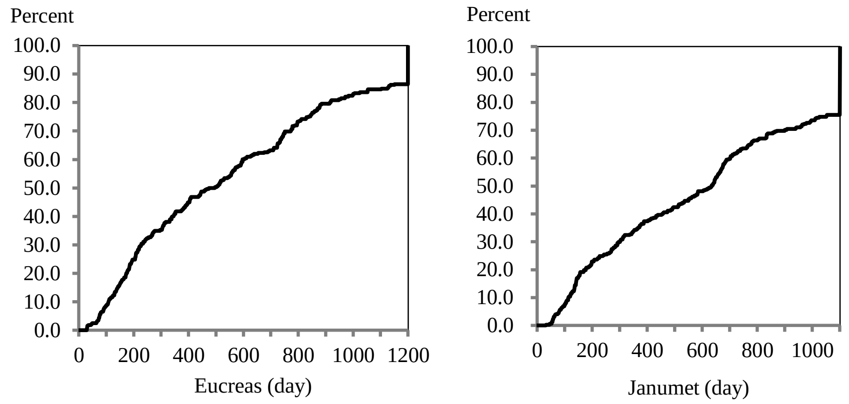
Garson [2013] suggests not inserting covariates correlating higher than 0.85 in Cox regression. For multiple highly correlated covariates (with coefficients higher than 0.85), only one variable from the set of intercorrelated variables is used. The correlation between the number of patients and the number of prescriptions was 0.95 – the number of patients determines the number of prescriptions written by specialists. As a result, the number of prescriptions was excluded from the analysis. Fairly high correlation (0.60-0.65) is found between two other sets of variables (mean number of consultations per patient vs. that of prescriptions per patient, and number of patients vs. portfolio width). Although neither variable from the set of intercorrelated variables is excluded from the model, their influence on the results is discussed later in this article.

3. Results

The proportion of specialists who have adopted the new drug up to the given number of days can be derived, if one minus the survival function is plotted. Eucreas was adopted by 86% of the specialists in 1200 days, whereas Janumet was adopted by 75% of the specialists in 1100 days. As shown in Figure 2, the new drugs were adopted gradually; no jumps or structural breaks can be detected in the diffusion process.

For both Eucreas and Janumet we have assessed the distribution of the survival times. The Q-Q plots (not shown in this article) revealed that none of the widely used distributions (such as the exponential, the log-normal, or the Weibull) fit reasonable to the empirical cumulative probability distribution of the survival times. As a result, this article uses the semi-parametric Cox regression model. This choice requires no assumption on the functional form of the probability distribution.

Figure 2. One minus survival function



Two hundred seventy five of the 318 specialists adopted Eucreas during the observation period. Table 5 shows the regression results for Eucreas – only the significant determinants of adopting this new oral anti-diabetic medication are listed.

Table 5

Significant determinants of adopting Eucreas

Variable	β	Standard error	Wald statistics	Degree of freedom	Significance	Exp(β)
Ratio for insulin (%)	–0.0213	0.0040	28.45	1	0.0000	0.9790
Portfolio width (number of brands)	0.1159	0.0224	26.74	1	0.0000	1.1229
Number of patients	0.0031	0.0008	15.83	1	0.0001	1.0031
Number of consultations per patient	0.8590	0.2486	11.94	1	0.0005	2.3609

Note. The omnibus test of the model suggests that the specified Cox model is suitable to the data at a significance level of 0.000. The parameters of the overall fit of the model are as follows: with 18 degrees of freedom the χ^2 is 154.063, whereas the –2 log likehood is 2654.596.

Source: Own calculation.

According to Table 5, if the number of patients increases ceteris paribus by one, then the probability of the specialist being an early adopter of Eucreas becomes greater by 0.31%. On average, if there is one unit growth in the number of consultations, then the probability of writing a prescription for Eucreas increases by 136.09%. Thus, strong relationship between specialists and patients forwards the idea that specialists – with the aim of finding the most appropriate therapy for their patients – use higher than average number of prescription drugs. Portfolio width is a significant determinant of new drug adoption as well. If the number of brands prescribed increases by one unit, then the probability of the specialist being an early adopter rises by 12.2%. Moreover, if the ratio of prescriptions for insulin decreases by 1%, then the probability of writing a prescription for Eucreas early ceteris paribus increases by 2.1%. Although in the medical literature the most appropriate therapy for anti-diabetic patients is matter of continuous debate, our results reveal that specialists prescribing proportionally less insulin are early adopters of new oral antidiabetic medications with higher probability. In addition to the determinants listed in Table 5, no other factors increase the probability of early adoption of Eucreas significantly.

Table 6

Significant determinants of adopting Janumet

Variable	β	Standard error	Wald statistics	Degree of freedom	Significance	Exp(β)
Portfolio width (number of brands)	0.1879	0.0239	61.63	1	0.0000	1.2068
Ratio for insulin (%)	–0.0271	0.0045	36.94	1	0.0000	0.9732
Proportion of loyal patients (%)	–0.0127	0.0042	9.29	1	0.0023	0.9874
Prescribing intensity (mean number of prescriptions per patient)	0.0784	0.0302	6.74	1	0.0094	1.0815

Note. The omnibus test of the model suggests that the specified Cox model is suitable to the data at a significance level of 0.000. The parameters of the overall fit of the model are as follows: with 18 degrees of freedom the χ^2 is 150.798, whereas the –2 log likehood 2356.785.

Source: Own calculation.

Although portfolio width correlates fairly highly with the number of patients (0.65), both variables increase the probability of early adoption significantly. Even though the number of consultations per patient correlates reasonably highly with the prescribing volume (0.64), in the final model only the former variable is included. When instead of the number of consultations per patient the prescribing volume is added to the Cox model, the prescribing volume becomes a significant predictor of new drug uptake. This finding is in in line with the recent systematic review of *Lublóy* [2014], where physicians with high total prescribing volume (or prescribing volume in the therapeutic class) seemed particularly alert to new drugs.

Two hundred forty of the 318 specialists adopted Janumet during the two-year observation period. Table 6 shows the regression results for Janumet (only the significant determinants of adopting this new oral anti-diabetic medication are listed).

Similarly to Eucreas, portfolio width and ratio of prescription for insulin are significant determinants of adopting Janumet. The influence of portfolio width on the adoption of Janumet is more pronounced than on Eucreas. Specialists writing higher number of brands adopt follower drugs earlier – most probably due to their previous positive experience with a drug having similar product characteristics. When the ratio of prescription for insulin increases, the probability of prescribing Janumet early decreases to a higher extent for Janumet than for Eucreas. Although for Janumet the number of patients and the number of consultations per patient do not influence the probability of early adoption significantly, the proportion of loyal patients and the prescribing volume are significant predictors of early adoption.

If the proportion of loyal patients ceteris paribus increases by 1%, then the probability of the specialist being an early adopter of Janumet decreases by 1.27%. For loyal patients, due to the efficient specialist-patient collaboration, specialists have already identified the most appropriate therapy even before the relatively late introduction of Janumet. For these loyal patients the most recently introduced oral anti-diabetic medications offer less benefits as compared to the drug already used. If the number of prescriptions per patient ceteris paribus increases by one unit, then the probability adopting Janumet early increases by 8.15%. For Eucreas, instead of the prescribing volume, the number of consultations per patient influenced new drug uptake significantly – however, these variables correlate moderately with each other.

4. Discussion and policy implications

Our results suggest that pharmaceutical companies should target their direct marketing campaigns at specialists with large patient panels. In particular, campaigns should be targeted at specialists who consult with their patients more frequently (Eucreas) or specialists who initiate anti-diabetic therapies for longer than average periods (the number of prescription per patient is high as in the case of Janumet).

The number of brands specialists prescribe is an influential predictor of new drug uptake. For both brands, the wider the prescribing portfolios, the earlier specialists adopt new drugs.

The ratio of prescriptions for insulin is also significantly associated with the rate of adoption for both brands – the higher the ratio of prescriptions for insulin, the later specialists adopt new oral anti-diabetic medications. The four possible explanations for delays in the adoption are as follows. First, the individual specialists may have convictions as to the most appropriate therapy (*Krentz–Bailey* [2005], *Scheen* [2005], *Davis–Abraham* [2011]), which may be related to therapeutic conservatism or to knowledge of and clinical experience with the new oral anti-diabetic medications. Second, patients with long disease histories had already received insulin, thus excluding new oral anti-diabetic medications as an alternative therapy (*Korytkowski* [2002], *Krentz–Bailey* [2005]). Third, for patients at severe stages of the disease, oral drugs are insufficient for keeping blood glucose levels low. Fourth, low-income patients cannot cover 30% of the drug price, whereas insulin is free of charge due to the state subsidy.

Relying on data mining, pharmaceutical companies might identify early adopting specialists from the database of Doktorinfo Ltd., based on the characteristics of prescribing new drugs early. (Specialists mentioned in this article can all be derived from that database.) To rollout new drugs successfully, data available for subscriptions fee from one single database may be sufficient to identify target specialists and distribute marketing efforts efficiently. Hard-to-obtain data such as specialists' socio-demographic characteristics, scientific orientations and practice characteristics are not necessary.

With the aim of accelerating new drug adoption and stabilizing the health status of patients with diabetes in initial stages, healthcare policy strategists should target their information leaflets and continuous medical education programs at three types of specialists. First, at key opinion leaders of endocrinology – collegial interactions with these opinion-leading physicians seem critical to fast, wide acceptance of pharmaceutical innovations. Second, at specialists with characteristics identified in this article (high number of patients, wide prescribing portfolio) – they accelerate new drug diffusion due to their prescribing and practice characteristics and most probably insert significant influence on their peers. Third, at specialists being less preferred by pharmaceutical companies – they have less patients, their prescribing portfolio is narrow, and treat relatively higher number of their patients with insulin.

Janumet should be preferred over Eucreas if healthcare strategists wish to allocate the limited healthcare budget more efficiently (treat more patients with one of the two recently introduced new oral anti-diabetic medications from the same budget). Assuming 70% state subsidy for both brands, if Janumet is preferred over Eucreas, the daily cost saving is HUF 13, totalling up to HUF 400 on a monthly basis. This policy implication assumes that both drugs reduce the HbAc1 level with close to equal efficiencies and despite distinct modes of action (*EMA* [2014]).

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This article employed Cox's proportional hazard model to identify factors influencing the likelihood of the specialists' initial adoption of the two most successful anti-diabetic drugs (Eucreas, Janumet). The semi-parametric Cox regression does not require the choice of some particular probability model to represent survival times, and is therefore more robust than parametric methods. Furthermore, Cox regression handles right-censored data appropriately – the sample included specialists who have not prescribed the studied drugs until the end of the observation period.

The significant determinants of new drug prescribing are the number of patients, the number of consultations per patient, the portfolio width of a specialist and the proportion of patients treated with insulin for Eucreas, and the variables of prescribing intensity, proportion of loyal patients, portfolio width and proportion of patients treated with insulin for Janumet. Variables identified as significant in this article (number of patients, number of consultations per patient, portfolio width) were associated with the likelihood of initial adoption in similar empirical studies (*Lublóy* [2014]).

This article has several possible limitations. First and foremost, *prescription data are incomplete*. Specialists' prescribing behaviours are monitored through the reported prescription data by general practitioners with whom specialists share patient care. All the sampled general practitioners listed the name/identification number of the therapy-initiating specialists, but only around one fifth of practicing general practitioners were sampled – specialists' routine adoptions of new drugs may therefore occur earlier. However, the sampled general practitioners are geographically representative, and the size of this bias is expected to be constant across specialists and does not undermine the validity of the results. Second, the *influence of professional and social interactions among specialists on new drug diffusion is not studied*. In the literature, interactions appear to be a very important influencing factor, information relayed through direct, personal contacts proving particularly powerful (*Coleman–Katz–Menzel* [1966], *Iyengar–Van Dan Bulte–Valente* [2011], *Manchanda–Xie–Youn* [2008]). Physicians' adopting behaviours are affected by other physicians' knowledge, attitudes, and behaviours, thus reducing safety and efficacy uncertainties. Third, *the marketing efforts of pharmaceutical companies targeted at physicians are not accounted for*. In the pharmaceutical marketing literature, the size and efficiency of marketing efforts targeted at physicians are very powerful predictors of new drug uptake (*Kremer et al.* [2008], *Manchanda–Xie–Youn* [2008], *Iyengar–Van Dan Bulte–Valente* [2011]). Fourth, *conclusions based on only two drugs from the same therapeutic class cannot be generalized*. By incorporating more drugs, future research may examine the determinants of new drug diffusion identified here for consistency by drug characteristics.

Appendix

Table A1

Determinants of adopting Eucreas – variables in decreasing order by significance

Variable	β	Standard error	Wald statistics	Degree of freedom	Signifi-cance	Exp(β)
Ratio for insulin (%)	–0.0213	0.0040	28.45	1	0.0000	0.9790
Portfolio width (number of brands)	0.1159	0.0224	26.74	1	0.0000	1.1229
Number of patients	0.0031	0.0008	15.83	1	0.0001	1.0031
Consultations per patient	0.8590	0.2486	11.94	1	0.0005	2.3609
Number of referring general practitioners	–0.0120	0.0068	3.14	1	0.0766	0.9881
Number of specialties	0.1291	0.0839	2.37	1	0.1238	1.1378
Prescribing intensity (number of prescriptions)	–0.0347	0.0272	1.62	1	0.2034	0.9659
Institution type (1 – clinic; 2 – university/teaching hospital; 3 – hospital; 4 – outpatient centre and other)	–0.1097	0.0882	1.54	1	0.2139	0.8961
Mean annual income of patients (in thousand HUF)	0.0000	0.0000	0.81	1	0.3688	1.0000
Location (1 – Budapest; 2 – large city; 3 – medium-sized city; 4 – small city)	–0.0539	0.0737	0.53	1	0.4648	0.9475
Gender of the specialist (0 – male; 1 – female)	–0.0698	0.1300	0.29	1	0.5913	0.9326
Ratio for old oral anti-diabetic medication (%)	–0.0093	0.0196	0.22	1	0.6360	0.9908
Position of the specialist (1 – head or deputy; 2 – chief physician; 3 – associate professor or physician)	0.0424	0.0980	0.19	1	0.6651	1.0433
Proportion of loyal patients (%)	0.0013	0.0039	0.11	1	0.7357	1.0013
Male patients (%)	0.0024	0.0088	0.07	1	0.7850	1.0024
Age of patients (years)	–0.0059	0.0241	0.06	1	0.8064	0.9941
Number of workplaces	–0.0233	0.0965	0.06	1	0.8094	0.9770
Age of the specialist (years)	–0.0014	0.0083	0.03	1	0.8702	0.9987

Source: Own calculation.

Table A2

Determinants of adopting Janumet – variables in decreasing order by significance

Variable	β	Standard error	Wald statistics	Degree of freedom	Significance	Exp(β)
Portfolio width (number of brands)	0.1879	0.0239	61.63	1	0.0000	1.2068
Insulin ratio (%)	–0.0271	0.0045	36.94	1	0.0000	0.9732
Proportion of loyal patients (%)	–0.0127	0.0042	9.29	1	0.0023	0.9874
Prescribing intensity (number of prescriptions)	0.0784	0.0302	6.74	1	0.0094	1.0815
Gender of the specialist (0 – male; 1 – female)	–0.2681	0.1391	3.71	1	0.0540	0.7649
Male patients (%)	–0.0183	0.0101	3.33	1	0.0681	0.9818
Number of specialties	0.1503	0.0939	2.56	1	0.1094	1.1621
Institution type (1 – clinic; 2 – university/teaching hospital; 3 – hospital; 4 – outpatient centre and other)	0.1293	0.0902	2.05	1	0.1518	1.1380
Number of patients	0.0010	0.0009	1.25	1	0.2643	1.0010
Ratio for old oral anti-diabetic medication (%)	0.0165	0.0197	0.70	1	0.4015	1.0166
Consultations per patient	–0.2364	0.2901	0.66	1	0.4151	0.7894
Mean annual income of patients (in thousand HUF)	0.0000	0.0000	0.38	1	0.5401	1.0000
Number of referring general practitioners	0.0037	0.0075	0.24	1	0.6253	1.0037
Age of patients (years)	–0.0091	0.0249	0.14	1	0.7131	0.9909
Number of workplaces	0.0244	0.0962	0.06	1	0.7997	1.0247
Location (1 – Budapest; 2 – large city; 3 – medium-sized city; 4 – small city)	–0.0126	0.0780	0.03	1	0.8718	0.9875
Position of the specialist (1 – head or deputy; 2 – chief physician; 3 – associate professor or physician)	–0.0082	0.1012	0.01	1	0.9351	0.9918
Age of the specialist (years)	–0.0007	0.0086	0.01	1	0.9370	0.9993

Source: Own calculation.

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Methodological Changes Affecting the Financial Accounts – Changes Implemented and Changes Postponed

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The comprehensive revision of national accounts and the related financial statistics is due in every 15–25 years, providing an opportunity for the international statistics community to review – in the light of developments in the economic and financial environment and changes in user requirements – the previously defined rules of methodological standards and to modify them as required, including fundamental changes. Of course, the modifications presented in the manuals are the results of serious compromises; indeed, the comparability of data in time and space, the availability of homogenous time series and broad-scale applicability are important requirements to be considered during the preparation or change of international standards.

These review and preparation efforts have led to numerous forward-looking recognitions in the recent revision period regarding the directions and areas of the methodological revision; however, most of them have not or only partially have been implemented. The author presents the main methodological issues that affect the system of national accounts in general, and the financial accounts in particular. Besides presenting the changes reflected in the data, the purpose of this paper is to give an insight into the reasons for the changes.

KEYWORDS:
National accounts.
System of National Accounts.
Financial statistics.

As a part of the system of national accounts, financial accounts constitute an area of financial statistics that present the financing and financial wealth of economic agents, sectors and the total economy. Accordingly, the compilation and presentation of national accounts are governed by the recommendations and rules of national accounts manuals (SNA[1], ESA[2]). Based on the division of labour within the official statistical service, in Hungary the compilation and quarterly publication of the financial accounts statistics are the responsibilities of the MNB[3]. Within the system of national accounts, financial accounts are fundamentally affected by the boundary of financial instruments – the types of assets and liabilities – through which the financing and financial wealth of the economy is presented, the valuation of these instruments in the statistics, the borderline between financial and non-financial transactions – ultimately, between financial and non-financial accounts –, and the sectoral breakdown in which stocks and flows are presented in the statistics.

For the most part, the latest international statistical methodology revision provided a more detailed breakdown of existing economic sectors and beyond this, it only introduced minor reclassifications between economic sectors regarding their content, slightly expanded the range of financial instruments (asset coverage) and moderately changed the delineation between financial and non-financial accounts (i.e. balancing items). The recording and valuation principles pertaining to transactions and assets remained essentially unchanged. In short, apart from a few modifications, the current financial accounts statistics present the same financial worth and financing flows as those before the methodological revision.

Regarding Hungarian statistical data, the most profound change involved the substantive expansion of the financial corporations sector to the expense of non-financial corporations, and the different recording of the takeover of private pension fund reserves in the accounts of general government and households. These topics are addressed at length below.

1. Expansion of the range of financial instruments

With the methodological revision, a number of new instruments – both financial and non-financial – were included in the system of national accounts as well as the

[1] SNA: System of National Accounts.
[2] ESA: European System of Accounts.
[3] MNB (Magyar Nemzeti Bank): Central Bank of Hungary.

related financial statistics. Regarding non-financial assets, some assets the use of which had been previously recorded as consumption have become capitalised (military assets, research and development). In the case of financial instruments, in turn, the statistical balance sheet was expanded to include certain, previously off-balance sheet contingent assets (standardised guarantees, employee stock options), while the recording of hitherto asymmetrically treated, special financial instruments was brought more in line with that of the rest of the financial instruments. It is another achievement that the implicit pension liability of social security system (pension claims of households) was included, at least as supplementary data, in the minimum required dataset of national accounts.

With respect to financial instruments it is a key question whether the asset types used so far cover the entire stock of financial assets, or there are additional instruments that should be regarded as financial instruments for certain reasons, such as out of prudence, for a more comprehensive presentation of risks or due to the progress of financial and capital markets. The difference between financial and non-financial instruments is the fact that financial instruments generally represent a claim against someone; they are assets that are recognised by someone else as liabilities. Instruments based on an unconditional obligation – where the parties enter into a straightforward debtor-creditor relationship or an ownership is established (cash, credit, deposit, debt security, equity) – traditionally belong to the category of financial instruments in any case. Subsequently, financial instruments were expanded to include items ensuring accrual accounting (other accounts receivable/payable). However, financial instruments related to contingent liabilities generally give rise to statistical difficulties, as it can be problematic to capture or evaluate such instruments or identify the counterparties participating in the transaction. Previously, from this category only financial derivatives and insurance technical reserves were treated as financial instruments in the national accounts and other financial statistics.

Insurance technical reserves are financial instruments recognised on the balance sheet of a financial intermediary (insurance company, pension fund) as special liabilities (provisions, reserves); however, they are typically not recorded (recognised) by the counterparty (policyholder customer, beneficiary) as an asset, and in many cases even the insurance company does not know (because of risk pooling) to which policyholder it carries the liability; this is established by estimates in the statistics. At this time, standardised guarantees – the guarantee type closest to non-life insurance – were included in the group of financial instruments. Standardised guarantees include transactions where the undertaking institution (financial intermediary or general government) issues standardised guarantees in large numbers, usually for fairly small amounts under the same scheme, and typically – as is the case with insurance transactions – it sets aside reserves (provisions) for calls under standardised guarantees, as the probability of calls can be predicted. Methodological manuals often cite guarantees for export credit and student loans as an example for this instrument.

The revised methodology of national accounts, therefore, divided guarantees into one-off and standardised guarantees and expanded the range of financial instruments to include the latter. The guarantees to be recognised as financial instruments in the statistics are those that are likely to appear as accounting items in the balance sheet (recorded in the form of provisions on the issuer's balance sheet); thus, statisticians will not have to face difficulties in obtaining the required information. The majority of guarantees, however, are one-off guarantees (provided to institutions based on individual assessments), and the related contingent liabilities continue to be excluded from the statistics. In this sense, the methodological change should be viewed as a symbolic step toward the right direction without a significant impact on statistical indicators. Its effect can be described as follows: the transfer to be settled due to the portion – percentage – of standardised guarantees likely to be called is included in the statistics as early as the disbursement of the loan (provision of the guarantee) instead of the payment to the beneficiary only upon its calling of the guarantee. (At least, the rules of methodological standards should be interpreted in this way in the case of general government.)

In our case, reviews preceding the methodological revision found that standardised guarantees were not typical either in export credit or in student loan contracts. However, under certain housing loan schemes supported by state guarantee, private borrowers participating in the scheme are entitled to state guarantee which is treated as a standardised guarantee in the national accounts under the new methodology. Although the state keeps a record of the guarantees provided by it, due to the specificities of budgetary accounting it does not recognise provisions to cover expected payments. For this reason, statisticians need to create insurance technical reserves, which are recognised in the financial accounts as the central government's liabilities to the creditor credit institutions. The government transfer previously recorded upon the calling of the guarantee becomes a financial transaction for the payment of the reserve under the new methodology, and the transfer to the credit institutions is recorded upon the inception of the guarantee, along with the creation of the reserve. In the Hungarian national accounts, the effect of the introduction of standardised guarantees is insignificant; it modifies the net lending of general government and credit institutions only by a few billion forints retrospectively for the past few years.

Provisions for calls under standardised guarantees (AF.66)[4] were included in the same group as insurance technical reserves (AF.6) among the instruments of the financial accounts. The same group includes some new technical items with no relevance to Hungary, such as the claims of pension funds on pension managers or their liabilities thereto. Due to the substantive expansion of the instrument group, its description has also changed in the international methodological standards, and

[4] AF stands for financial assets.

is now referred to as "insurance, pension and standardised guarantee schemes". Since the significance of the newly introduced instruments is negligible in the Hungarian practice, the previous description of the instrument group has been retained and this group is still referred to as "insurance technical reserves" in the financial accounts.

Employee stock options (AF.72) comprise another new financial instrument introduced by the methodological revision. They were classified under financial derivatives (AF.7), which were removed from the group of securities other than shares and are now presented as a separate main instrument. As a financial instrument, an employee stock option represents households' claims against employers that offer a portion of their employees' compensation in the form of corporate stocks. Statistical methodologies have been familiar with the concept of the employee stock option; however, they recognised only actual share allocations as a compensation of employees, upon their execution. According to the new methodology, compensation of employees must be recognised from the vesting date in the non-financial accounts and not when the option is actually exercised and, parallel to this, a matching liability of the employer toward the employee (household sector) must be recorded. The exercise (call) of the option (payment of the benefit in kind), therefore, is a purely financial transaction, i.e. the employer's payment of the option liability. Since this instrument plays only a minor role in the Hungarian practice, no estimates have been made so far in the financial accounts for employee stock options, and the compensation of employees continues to be recorded in the non-financial national accounts in accordance with the previous methodology, upon the transfer of the shares.

The presentation of both standardised guarantees and employee stock options as financial instruments in the national accounts may be viewed as the recognition of the new recording practice that has been already introduced in many places. In several countries, the insurance technical reserves reflected in the statistics of insurance companies or other financial institutions undertaking guarantees already included provisions for the standardised guarantees granted by them, or the financial derivatives deriving from corporate reports may also have included a portion of employee stock options. The primary significance of the introduction of the new rules pertaining to these items is the fact that these instruments will not be included in future statistics occasionally.

The main substantive change affecting financial instruments (in line with the balance of payments statistics) is the recording of monetary gold (AF.11) and SDR[5] (AF.12) as liabilities and not only financial assets. For the most part, this eliminates the discrepancy between the net liabilities of the national economy and the net receivables of the rest of the world, which stemmed from the classification of monetary

[5] SDR: special drawing rights.

gold and SDR among resident assets (central banks) without being offset by any non-resident liabilities under the previous methodology. Consequently, from now on only the gold bullion held by monetary institutions as an international reserve asset will retain its specific characteristic feature, giving rise to asymmetries in the financial accounts. Under the new methodology, allocation and cancellation of SDR are achieved through transactions instead of other changes in volume as in the past. This also means that the SDR allocated by the IMF[6] will also become the liabilities of residents (central banks); in other words, SDR are not created from scratch but are lent to monetary authorities.

In principle, the most profound change brought about by the expansion of the range of financial instruments is the quantification of social security pension liabilities in the framework of the national accounts. While pension liabilities linked to pay-as-you-go pension schemes are still not recognised in the core national accounts according to the international statistical methodology standards, the implicit pension liabilities of social security schemes will have to be presented as supplementary data in future, along with their annual changes. All EU member states are required to submit a report on these figures from 2017 onwards, as part of their annual data transmission related to national accounts. In Hungary, the MNB assumed responsibility for carrying out the methodological and data compilation tasks related to the statistical recording of pension liabilities.

2. Changes in the valuation of instruments and transactions

The methodological principle of recording the stocks of financial instruments at current market value did not change with the introduction of SNA 2008 and ESA 2010. Instrument types without a secondary market or appropriate valuation method (loans, deposits, other accounts receivable), however, must be traditionally presented at nominal value in statistics (nominal value replaces market value in their case). The change in their valuation resulting from the methodological revision lies in the fact that nominal value is now understood as gross face value; in other words, accrued interests must be added to the capital stock of each instrument. Until now, this was merely a recommendation, leaving the option of recording accumulated (accrued) interests among other accounts receivable/payable. (Since Hungary has always regarded accrued interests to be a component of interest-bearing instruments, the methodological revision did not affect its financial accounts in this regard).

[6] IMF: International Monetary Fund.

Thus, the instruments actually subjected to market valuation in the financial accounts are debt securities, equity, insurance technical reserves, and financial derivatives. Among the stock of shares and equities, other equity existing in a form other than share (security) did not have to be evaluated at market value even in the past; it could be recorded on the balance sheet at nominal value or book value. Now, however, the elimination of the obligation of valuation at market price represents a step backward in the valuation of another instrument of equities, unquoted shares, as well.

Previous methodological manuals for the national accounts specifically prescribed market valuation for unquoted shares; in fact, ESA 95 even provided a calculation procedure for this, although it was rarely applied. At the beginning of the 2000s, Eurostat launched a project to develop a uniform pricing practice for unquoted shares; it produced methodological documents and started to build an EU-wide database broken down by activity classes from the data of listed companies. A few years ago, however, its initiative aimed at the pricing of unquoted shares came to a halt, given the limited number of countries taking an active role in the project and the fact that few countries took advantage of its results. In addition to unsuccessful European financial account initiatives, the easing of valuation rules was the consequence of the fact that, due to the different breakdown of instruments, the boundary of instruments to be presented at market value and at book value is different in balance of payments statistics. (For the most part, unquoted shares are among FDI[7], to be presented at book value. Balance of payments experts decided to apply the book value (of the issuer company) in the case of unlisted equities for the sake of consistency between the foreign direct investments of different countries.)

In Hungary, only about one percent of corporations operate as companies limited by shares, and among them, there is only one company out of a hundred whose shares are quoted on the stock exchange. (The number of companies whose shares are actively traded is even lower.) This extremely limited group of listed companies is insufficient to provide a basis for the pricing of unquoted shares and equities. The new methodological manuals permit the presentation of unquoted shares at the book value of the issuer companies' shareholders' equity in the financial accounts. Consequently, the solution applied henceforth by Hungary and several other countries has been accepted even at the level of methodological recommendations, and the methodological difference between the financial accounts and the international investment position statistics of the balance of payments has been eliminated. At the same time, this rendered the category of revaluation all the more unreasonable in the case of unlisted equities, which became a technical item trying to create a link between the differently valued stocks and transactions.

[7] FDI: foreign direct investments.

Methodological manuals still fail to address two, seemingly negligible items with respect to shares: what to do with repurchased own shares (can the issuer company have a claim against itself) and negative own funds (can the claim have a negative price and stock value). In reality, the (negative) answers can be derived from general methodological rules; however, different statistical areas apply different solutions for practical reasons. It would have been worthwhile to lay down these rules, as well, in the manuals.

However, it is a step forward that, in the preparatory phase of the methodological revision, a separate working group was designated to develop proposals about changing the valuation of loans. It appeared as though the working group succeeded in shifting from the practice of recording loans at nominal value by allowing loan stock statistics to reflect the effects of changes in market interest rates and the uncertainty of repayment. Obviously, a revision of the pricing of stocks would have called for the reconsideration of the contents of transactions, earnings (property income) and write-offs; in addition, changing the valuation of loans could have also set off the reform of the valuation of other instruments without a secondary market. However, the statistical community was unprepared for a conceptual shift of this magnitude at this time. (In the case of unquoted shares, the obligation of market valuation has just been revoked). Thus, ultimately, the previous regulation pertaining to the valuation of loans prevails in core accounts and balance sheets, while it has become possible to present bad loans at net value in the supplementary table.

The reinforcement of previous loan valuation rules also implies that international institutions will be even more determined to ensure that individual countries comply with the rules concerned. This, however, is a daunting task sometimes; indeed, data suppliers themselves tend to revalue their claims, and special statistical reports are required to provide data regarding the original (gross) amounts, nominal values. Beyond technical obstacles, a form of methodological resistance may also have been behind the disregard for the rules in the case of some statisticians. In this respect, the question arises about the extent to which a basic principle of statistics (i.e. it is not permitted to record assets or liabilities the recovery of which is unlikely) is adhered to. Why are some loans still recorded in statistics at original face value when it is obvious that they will not be repaid (in full) in any case? In addition, some of them are now accompanied by a new, artificial instrument in the form of standardised guarantees, which has to be set aside as early as disbursement (borrowing) in recognition of the fact that the loan will not be recovered. (This is why a financial institution with accounting losses only receives transfers; for statistical purposes such an institution does not incur a loss at all as it recognises the loan in its original state until it is repaid or written off). Hopefully, these contradictions will be eliminated at the next methodological revision 15 years from now.

3. Delineation between financial and non-financial transactions

In our case, the most significant and far-reaching methodological change affecting data content is the different recording of return into the public pension scheme from private pension funds in the national accounts. The recording problem is caused by the fact that pension liabilities may not be presented in the statistics in the social security pension schemes – this is permitted under the new methodology only in a segregated manner, in the form of supplementary data –; therefore, pension liabilities accumulated in corporate or financial intermediary pension funds cannot be transferred to general government upon the return of members or when the state takes over the corporate pension fund reserves. Upon the transfer of assets, all existing pension liabilities (insurance technical reserves) must be eliminated, utilised or written off, as they cannot be interpreted in the system of national accounts in the case of general government. The mismatches resulting from the different statistical treatment of the two types of pension schemes cannot be fully resolved; data in the national accounts will be biased inevitably. The question is whether this bias should be incorporated concentrated in time or spread out retrospectively or in advance. Previous methodological standards recommended one of these possible options, while the new standards prescribe a new solution.

According to the previous national accounts methodology, the government's takeover of pension fund reserves upon exits from employer or private pension funds was recorded as a one-off capital transfer to general government, which increased the net lending of general government (reduced government deficit), and reduced the net lending of the sector (corporations or households) providing the transfer. Under the new methodological rules (assuming that the funds are in balance), the transfer of wealth cannot affect the balances of sectors at the time of the exit, and other accounts payable (AF.89) to households with an amount corresponding to the assets taken over must be recorded in general government's balance sheet. These amounts must be decreased in the form of current transfers during subsequent pension disbursement periods. This means that, instead of the previous, concentrated effect, the effect on net lending will now materialise in the accounts of households and general government spread over time.

Since general government's other accounts payable are not part of the consolidated, gross government (Maastricht) debt (measured at face value), the change in the recording practice will have no effect on the statistical public debt ratio. At the same time, the recording of other accounts payable reduces the net financial worth of general government, which has the opposite effect on households' net financial worth. The new recording practice eliminates the drastic, one-off net lending or net borrowing of households and general government at the time of the asset transfer, and the extreme jump (level shift) in the net financial worth of the two sectors also disappears. Indeed, the incorporation of other accounts payable offsets the stock of the financial instruments taken over in the balance sheet of the central government, while the corresponding amount of other accounts receivable replaces the loss of insurance technical reserves in households' balance sheets. Therefore, these new other accounts receivable/payable behave as if social security pension liabilities were recorded in general government's balance sheet, while methodological manuals emphasise the non-existence of such an item, pointing out that this is only a prepayment, arising from the fact that households have paid their pension contributions into the central budget in advance.

According to the previous methodological standards, a capital transfer of HUF 2 856 billion was recorded in domestic statistical accounting in the wake of pension fund asset transfers between 2009 and 2013 which, in this period and particularly in 2011, increased the net lending of general government and reduced that of households. Under the new methodology, a corresponding amount of other accounts payable was recorded for general government vis-à-vis households. According to the new model, the accounts payable will be reduced in annually increasing amounts during a period of 35 years, offset by current transfers. Other accounts receivable/payable are generally short-term, technical instruments in the financial accounts, intended to serve accrual accounting, i.e. to bridge the timing differences between economic events and their financial settlement. No interest income is recorded for such technical items in the national accounts. The present case, however, involves a rather long-term instrument, and its value is preserved by recording, in line with the methodological standards, an interest income on the amount in question. Households receive this amount from general government (on the non-financial account) and reinvest it (on the financial account) on a continuous basis. Due to their significance, other accounts payable/receivable as well as their changes are also presented separately as memorandum items in the Hungarian publications of the financial accounts.

The more accurate definition of the content of property income also affects the delineation between financial and non-financial transactions. It is a step forward that methodological manuals have made it clear: the owners of investment/mutual fund shares are entitled to the income earned by the funds on their assets and investments (reduced by operating costs) even if such incomes are not paid out in the form of dividends (i.e. the reinvested income must be recorded). Although this was reflected in the methodology even in the past, in many cases the national accounts and balance of payments statistics did not include the required corrections. From now on, it will be easier to identify incomes and to control their recognition in statistics as a new income category was created in the new standards for the presentation of the income of mutual fund shares, divided into dividend and reinvested earnings.

Beyond clarifying the income of investment fund shares, some changes affect the definition of the property income of shares and other equity. The concept of super-dividend applied in balance of payments statistics and general government statistics has been extended to all ownership linkages, i.e. to all holder sectors and all investment forms. Super- or extraordinary dividend is the portion of the dividend that is not covered by the operating surplus of the current year but paid from the profits of previous periods retained in the company. Statisticians must separate this excess dividend and record it as a withdrawal of equity rather than property income (i.e. transfer this amount from the non-financial to the financial account). As a result, statistics will reflect less dividend than voted by the shareholders of the companies, property income will be capped and brought more in line with the after-tax or the operating profit. However, owing to conceptual uncertainties, hard-to-interpret rules and the data and resource intensity of calculations, it does not appear likely that many countries will opt for extending the separation of the superdividend to other holder sectors beyond the rest of the world and general government. The conceptual uncertainties are caused by the slightly different definition of the superdividend in the balance of payments statistics and general government statistics, and this ambiguity persisted even after the methodological revision. The basis on which current year dividend is reclassified into withdrawal of equity is ambiguous: should this dividend be an outlier relative to the company's result in the previous year or relative to the usual dividend payment?

Although the modification of the statistical rules of dividend accounting was aimed at standardisation, the results might appear to be merely symbolic. In principle, the application of the category of superdividend limits the dividend income presented in statistics to the level of earnings (the withdrawal of the surplus becomes a financial transaction). However, dividend remains to be a form of property income that is due and payable upon the shareholders' vote. Despite the promising initiatives, beyond FDI, the concept of reinvested earnings was not extended to other ownership/equity linkages. Under the new methodology, companies remain to be institutional units entitled to do business independently and as such, they have a right to retain their profits; shareholders are not entitled to the profits automatically. In this regard, reinvested earnings on foreign direct investment are an exception; those formulating the standards were unable to convince decision-makers to accept a general definition of and relevant rules for additional exceptions that arose, such as the reinvested earnings of government-owned (public) companies. The general application and extension of the category of reinvested earnings to all companies and shareholders would require a complete reconsideration of the concepts of institutional independence and shareholders' income, which was beyond the scope of the latest revision period.

4. Changes in the content of economic sectors

The delineation between the sector of financial (S.12)[8] and non-financial (S.11) corporations in the national accounts produced in compliance with the new methodology has changed (through reclassifications – substantive change), and the financial corporations sector is now presented in greater detail, broken down into more sub-sectors in the statistics (structural change). Regulations have been tightened regarding the content of the government sector and accordingly, as a result of organisational reclassifications from the corporate sectors, the range of institutions classified into the general government sector has been expanded. Sector changes affect financial and non-financial accounts alike; however, institutional reclassifications due to methodological reasons influence financial wealth and debt ratios more significantly, with a more pronounced effect on financial accounts.

Under the new methodological standards, the group of financial services in the statistical sense and, consequently, the contents of the financial corporations sector have been expanded. Contrary to earlier practice, in addition to the financial intermediaries connected to the public, corporations providing financial services to a limited group of clients, typically within a corporate group, must also be regarded as financial corporations in the new statistics. These corporations must be reclassified from the non-financial corporations sector to the financial corporations sector. A holding or group financing company that engages in passive financial intermediation within the corporate group – and qualifies as an independent institutional unit – must be classified into the category of captive financial institutions (S.127), a newly created sub-sector within the financial corporations sector. SPEs[9] that are in relationship solely with non-residents and fulfil passive financial intermediary functions among non-resident corporate group members have been transferred from non-financial to financial corporations. The reclassifications entail a decline in the stock of financial assets and liabilities of the non-financial corporation sector, and a corresponding increase in the financial assets of financial corporations in the financial accounts.

In our case, the sectoral changes are primarily reflected in the financial accounts that include SPEs. A half of the financial assets and nearly a third of the financial liabilities of the non-financial corporation sector are transferred to the financial sector, with the creation of a new sub-sector (captive financial institutions) corresponding in size to the credit institution sub-sector. This is the most large-scale and most remarkable change in the Hungarian financial accounts statistics engendered by the methodological revision. The significant shift in wealth can be attributed to the fact that certain companies (SPEs) of substantial financial wealth operating in Hungary

[8] S stands for institutional sector.
[9] SPE: special purpose entity.

and providing passive financial intermediation between non-resident counterparties were regarded as non-financial corporations under the previous methodological standards.

Figure 1. Liabilities of financial (S.12) and non-financial (S.11) corporations sectors (including SPEs) in percentage of GDP according to the previous and the new methodology

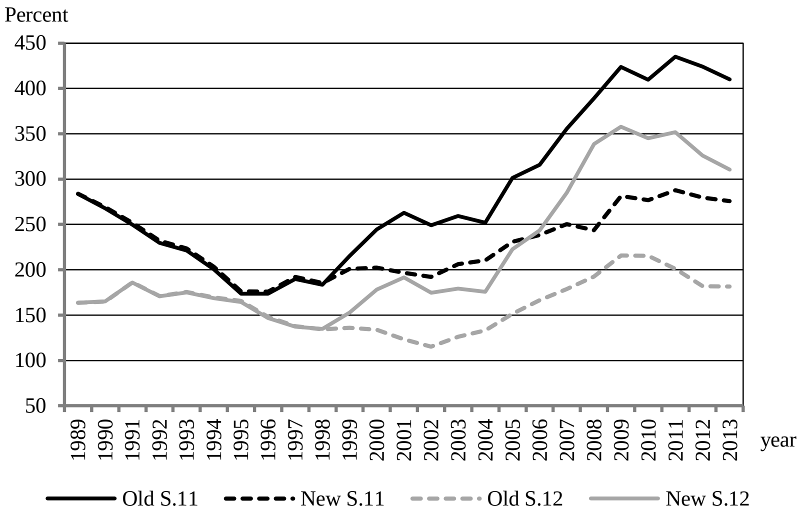
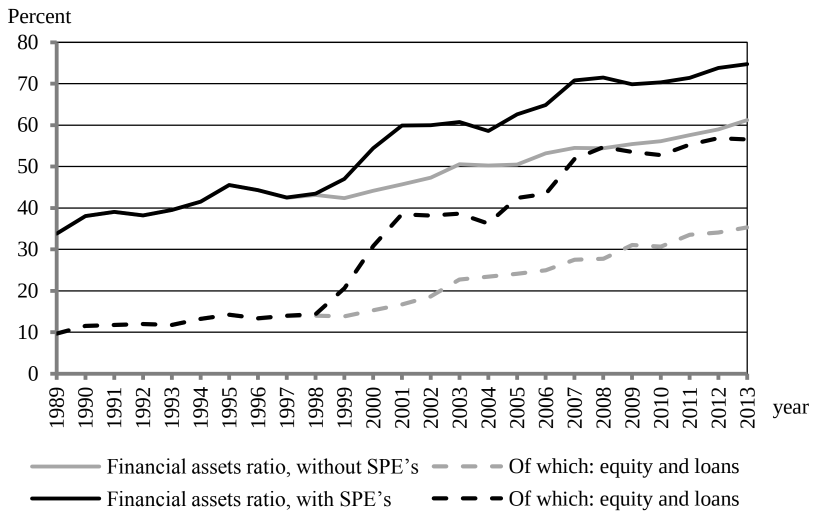


Figure 2. Financial assets of non-financial corporations in percentage of liabilities in financial accounts according to the previous methodology, with and without SPEs



Looking at the 25-year corporate time series, it is apparent that financial assets represent an increasingly large share within the assets of non-financial corporations over time. The gaining ground of the balance sheet structure characterising financial intermediaries in the non-financial corporate sector (which, by definition, offers products rather than financial services) is attributable to the increasing prominence of intercompany lending and the strengthening of ownership linkages among non-financial corporations. In recent decades, numerous groups and ownership chains have emerged where a part of the member companies perform holding or group financing activities, and their function within the group became the holding of other companies or the provision of credit. As they are not connected to the public, they do not need a license for performing financial activities and as such, these companies were not – and still are not – considered to be financial intermediaries in the methodology of national accounts. While previously only financial intermediaries and financial auxiliaries belonged to the sector of financial corporations, as a result of the methodological revision, now other financial service providers constitute a part of the sector as well.

In reality, previously published methodological manuals did not offer any guidelines with respect to the definition of an economic sector for captive financial institutions or companies with passive financial functions. One of the accomplishments of the revised methodological standards is the effort to define these special institutions and to provide rules regarding their sectorisation. To put it simply, under the new regulation companies that predominantly hold financial instruments and do not provide any services other than financial services are to be considered financial corporations. Thus, the methodological standards reinforce the sectorisation practice already existing in several countries. Policy-makers may have thought that they had cleansed the sector of non-financial corporations from the provision of financial services and the related financial instruments and property incomes. In addition, these special activities and institutions do not even disturb the presentation of traditional financial intermediation, as they are included in an independent sub-sector (captive financial institutions) within the sector of financial corporations.

However, they failed to consider the consequences of the sectoral realignment thoroughly; indeed, the countries affected faced – and will face – these consequences belatedly, upon the application of the prescribed rules. As a negative effect, the reclassification breaks up the group of companies previously included in the same sector, and numerous companies are now considered to be independent institutional units when they should not be, as they have no real economic activity and function as mere passive owners or money channels of a group. While the corporate sectors are limited to market producers, an independent sub-sector was created for companies that are obviously non-market producers, and their production, output and value added cannot even be measured. It is done at a time when the use of consolidated corporate accounting data has gained ground in the statistics, along with group formation and the consolidation of auxiliary units that serve central units or corporations with an output. In addition, the weight of mixed function corporations – those functioning as money channels inseparable from the company while also performing normal production or service provision activities – has increased as well. Thus, despite all good intentions and insights, the methodological revision does not necessarily mitigate the differences between the sectorisation practices of individual countries. Some countries will classify holding or group financing corporations into the sector of financial corporations, while others – in the lack of registers and specific data – will not be able to do so.

The new international methodological standards break down the financial corporations (S.12) sector into nine sub-sectors instead of the previous five, with the level of detail of other economic sectors remaining unaltered. Within the sub-sectors of financial corporations, the central bank (S.121) sub-sector and the financial auxiliaries (S.126) sub-sector correspond to the former ones, while each of the previous sub-sectors of other monetary institutions, other financial intermediaries and insurance corporations and pension funds is now broken down into two sub-sectors. In addition to the former sub-sectors, captive financial institutions (S.127) have been added as a new sub-sector. The more detailed sectoral breakdown of the financial corporations sector provides an opportunity to present and analyse the assets and liabilities of various mutual funds segregated from other institution groups, and similarly, the data of insurance companies and pension funds are presented separately in the financial accounts.

There are mandatory and optional categories to be used for the purposes of international data transmissions both in the areas of sectorisation and in the breakdown of instruments. It was possible to present the previous financial corporations sector with three consolidated sub-sectors instead of five sub-sectors, if a country chose to compile its national accounts according to the minimum level of detail. Similarly, the new data supply requirements can be met by presenting six – more consolidated – sub-sectors instead of nine. In the Hungarian financial accounts, however, financial sub-sectors are presented at the maximum level of detail, providing ample opportunity for data analysis and the verification of data quality. It is a particularly remarkable achievement that separate categories were created for such different institution groups as money market mutual funds and credit institutions as well as other (non-money market) investment funds and other – typically creditor – financial intermediaries. At long last, it has become possible to examine the financial wealth, investment and financing processes of credit institutions or various investment funds separately, based on consistent data included in the financial accounts.

By tightening the so-called 50 percent rule intended for the segregation of market and non-market producers, and by including corporations providing services solely to the government in general government sector, the ESA 2010 and the Manual on Government Deficit and Debt expanded the range of institutions belonging to the general government sector. In addition, the manuals stipulate specific sectorisation rules for a number of special financial and non-financial organisations (bad banks, strategic stock holding organisations, state holding companies, guarantee undertakers, certain non-profit organisations, etc.). The application of the new rules increases the number of financial and non-financial corporations and non-profit organisations included in general government; their net borrowing alters the government deficit, and the debts of the reclassified organisations increase the Maastricht debt of the government sector.

Even the previous methodological manuals included recommendations about breaking down the data of corporate sectors by main owner sector. Within the sectors of financial and non-financial corporations, this provided an opportunity to generate and publish the accounts of company groups in majority government ownership as well as those held by non-residents and private sectors. The new methodological standards attach special significance to the national accounts of companies owned (directly or indirectly) by general government, as they allow for the presentation and analysis of the public sector as a whole, in addition to general government (government sector). In line with the recommendation, the MNB has commenced the compilation of the annual financial accounts of public companies.

5. Changes linked to the general data revision of financial accounts

It is a basic requirement of national accounts statistics to have long, homogeneous time series available for users. With that in mind, the entire length of the time series must be updated to reflect the effects of the methodological revision, the separation or reclassification of sectors and instruments and the effects of the changes in valuation or recording principles. For the purpose of this exercise, previously used data sheets must be re-examined with the possible inclusion of additional data sources, and all calculations and estimates underlying the published time series must be repeated (in more detail or in a different breakdown). This provides a good opportunity to perform any data revisions necessitated by other reasons, and to incorporate the results of other enhancements into the statistics. Thus, simultaneously with the implementation of the changes to the international methodological standards, new data sources will also be incorporated and data corrections will be carried out, along with the revision of the estimation and calculation procedures used in the financial accounts. This comprehensive data revision affected the time series of all economic sectors, especially those of households, non-financial corporations and the rest of the world.

Since neither the financial accounts nor the underlying statistics include direct data collections pertaining to households, the stocks and flows of households' financial assets and liabilities are estimated by relying on the data supplies of financial intermediaries or counterparty sectors. The greatest deficiencies observed affect the coverage of households' foreign financial instruments (issued by non-residents or held abroad); indeed, in this case it is not possible to request information directly from non-resident counterparties in order to obtain data for measuring the financial assets of resident households. Parallel to the methodological revision, the results of some enhancements have also been incorporated, including those allowing for a more comprehensive presentation of data pertaining to resident households' holdings of foreign currencies, foreign bank deposits and foreign equities in balance of payments statistics and the financial accounts. The aggregated stock of bank deposits held abroad is calculated on the basis of foreign banks' data (obtained from foreign central banks) pertaining to Hungarian households. The stocks and flows of households' foreign direct investments (shares, other equities) are defined based on the foreign dividend income shown in the annual personal income tax returns. Despite the recent enhancements, the coverage of the foreign financial assets and liabilities of Hungarian households in the financial accounts is still not complete; however, significant results have been achieved with respect to the monitoring of these instruments and consequently, the financial assets of households presented in Hungary's statistics increased by hundreds of billions of forints.

In addition to households' foreign financial instruments, data on loans granted/ borrowed by households to/from non-financial corporations as well as estimates on equity held by households have also changed. Loans outstanding more than tripled based on the recalculations, and loans extended by households to their companies amount to HUF 900 billion compared to the previously estimated HUF 250 billion. The equity investments of households in resident companies have been defined with more precision primarily on the basis of flow data derived from end-of-year stock data through complex calculations at the corporate level. More intense utilisation of corporate annual reports and corporate tax return as well as more accurate calculation procedures improved the quality of the presentation of households' assets and liabilities vis-à-vis non-financial corporations. Along with the data of financial instruments, their property incomes presented in non-financial accounts changed as well.

The more complete use of administrative corporate data sources (tax returns, annual reports) and data corrections allowed for a more accurate distinction and estimation of intercompany loans, equity and other accounts receivable of non-financial corporations. Although the level of intercompany assets and liabilities does not impact the balancing indicators, they affect gross data, financial wealth and debt figures; therefore, the quality of such data is important. Intercompany loans did not change significantly as a result of the data revision; however, the separation of long-term and short-term loans has been achieved, which rendered the maturity breakdown of corporate accounts more accurate. (Previously, all intercompany loans were included in the short-term category). The stock of intercompany trade credits and advances increased in general; however, data were revised downward for certain years due to the correction of reporting errors.

Besides the methodological revision and data correction, changes in data pertaining to the rest of the world and the total economy can be attributed to the fact that the previously existing technical discrepancies between the balance of payments statistics and the financial accounts have been eliminated. Consistency between the two types of statistics has improved with regard to the applied instruments as well.

6. Changes in the presentation of data and the scheduling of the data dissemination

Hungarian financial accounts statistics are essentially available on the MNB's website in the form of quarterly time series starting from 1990. Data are updated on a quarterly basis: preliminary financial accounts are prepared regarding the financial assets and financing of households and general government for the 1.5 months following the current quarter; the comprehensive set of financial accounts for all sectors are available three months following the current quarter. There are no separate, annual statistics; annual accounts are generated from quarterly data.

The effects of the methodological revision and the comprehensive data revision were first reflected in Hungarian financial accounts in the comprehensive data release for the 1st quarter 2014. Starting from the publication of the comprehensive financial accounts for the 1st quarter 2014, the data release deadline changed from the first working day of the fourth month following the reference period to the last working day of the third month following the reference period. At the same time, the publication dates for the preliminary financial accounts pertaining to the general government and households remained unchanged. It was the earlier publication of the quarterly balance of payments statistics – i.e. the main data source – that allowed for the earlier compilation of the full set of financial accounts. If the lead time was reduced further, financial accounts statistics would be released earlier than the non-financial accounts of the national accounts, which would not ensure harmonised data dissemination. This would be particularly problematic in the case of the March and

September publications, which overlap with the compilation and dissemination of the EDP[10] notification – that relies on both parts of the national accounts –, and usually require last-minute data reconciliations and corrections.

The structure of the published tables was subject to minor changes in the wake of the methodological revision and the comprehensive data revision, with the introduction of the sectoral and instrument breakdown presented in the time series and summary tables, in line with the new methodological requirements described earlier. The time series tables remain the backbone of the publication, showing stocks and flows of financial assets and liabilities broken down by economic sector. As a novelty, in addition to quarterly time series, annual time series are also published. In addition to general tables presenting an instrument breakdown equally applicable to all sectors, detailed financial accounts are produced for the sectors of households, general government and non-financial corporations, with a more detailed breakdown – by type, counterparty or currency – of the assets and liabilities specific to the given sector.

While international institutions require financial accounts with the inclusion of resident SPEs, in line with the balance of payments statistics, normal financial accounts (excluding SPEs) are in the core of Hungarian data disclosures. Nevertheless, as another change compared to previous publications, in addition to the presentation of the normal quarterly data tables, versions including SPEs for all time series tables will also be available. (Previously, only annual cross-tables were released from the data that included SPEs.) For the purposes of transparency and data protection, normal tables not including SPEs present the sub-sectors of other financial intermediaries (S.125), financial auxiliaries (S.126) and captive financial institutions (S.127) in a consolidated fashion under the heading “other financial corporations”. (The more detailed breakdown of the sector of financial corporations may lead to the presentation of protected individual data – especially in the case of a detailed breakdown of counterparty sectors and instruments –; therefore, the level of detail should be restricted for data releases.)

7. Summary

The latest revision of the methodological standards of national accounts did not entail fundamental changes in the balancing indicators of the financial accounts. In Hungarian statistics, the only significant change in main indicators resulted from the modified recording of the asset transfer of private pension funds to the government.

[10] EDP: excessive deficit procedure.

The effect of the methodological revision is primarily reflected in the increased level of detail, which provides an opportunity for more broad-scale use of the financial accounts. Naturally, the expansion and more detailed presentation of the data released could be implemented at a country's own initiative, even without an international methodological revision; however, the methodological revision guarantees that the detailed breakdown of data is consistent with the concepts and categories applied by the rest of the countries, ensuring comparability between the statistics at the level of details as well. In addition to technical or presentation-type changes, the revision of the standards brought to the surface numerous pressing substantive or methodological issues. Among them, redefining the category of financial services activities and modifying the delineation between financial and non-financial corporations exerted the most significant impact on the data presented in the financial accounts. As a positive development, among other things, the new manuals pointed out the significance of measuring and presenting implicit social security pension liabilities and bad loans and, if only in the form of memorandum items, these figures have become a part of the data underlying the national accounts.

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Adjusted Czech, Hungarian and Slovak Fertility Rates Compared with the Traditional Total Fertility Rate*

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In this paper the Czech, Hungarian and Slovak fertility trends are compared between 1970 and 2011, using four different fertility rates. Three of them are calculated period fertility indicators (traditional total fertility rate, Bongaarts–Feeney tempo- and parity-adjusted total fertility rate, Kohler–Ortega tempo- and parity-adjusted total fertility rate), while the fourth measure is the observed completed cohort fertility rate. It is demonstrated that between 1990 and 2011 the adjusted fertility numbers were higher than the total fertility rate in all three countries, but they didn't reach the replacement fertility level. By comparing the period and completed cohort fertility rates, the most accurate fertility indicator is selected. The authors state that until 1977 (while the mean age of women at the birth of their first child decreased in the Czech Republic and Hungary (but not in Slovakia)), the Kohler-Ortega adjusted fertility rates performed best for the first parity, but for the second and third birth orders and from the mid-1970s for of all birth orders the Bongaarts–Feeney adjusted fertility rates gave closer approximation of the completed cohort fertility in each of the countries.

KEYWORDS:
Fertility.
Central and Eastern European countries.

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The systematic analysis of fertility trends has become part of the scientific research since the second third of the 20th century. Contrary to the theory of overpopulation by *Malthus* [1798], nowadays the main problems are the low number of live births and the decreasing population in developed countries (*Neyer* [2013]). In certain cases – for example when calculating primary school places – it is enough to define the number of new-borns. However, during longer periods and in complex economic analyses – in studying, for example, the sustainability of the pension system or the human factors of the economic growth – we must pay attention to the indicators of fertility rates as well. Up to now the most widely used traditional indicator for measuring period fertility has been the so-called TFR[1] that might provide misleading estimate of a woman's average number of children (*Rallu–Toulemon* [1994]; *Bongaarts–Feeney* [1998], [2004], [2006], [2010]; *Kohler–Ortega* [2002]; *Yamaguchi–Beppu* [2004]; *Goldstein–Sobotka–Jasilioniene* [2009]; *Sobotka–Lutz* [2011]; *Bongaarts–Sobotka* [2012]; *Berde–Németh* [2014]).

This indicator can estimate the fertility properly if the parity composition of women of reproductive age, the timing of childbirth and the distribution of women upon other demographic characteristics are unchanged. However, in periods during which women's mean age at the birth of their child increases, the TFR may be biased. Many authors have pointed out that decreases/increases in the TFR can be attributed to the so-called tempo effect[2] (*Philipov–Kohler* [2001], *Kohler–Billari–Ortega* [2002], *Husz* [2006], *Goldstein–Sobotka–Jasilioniene* [2009], *Frejka et al*. [2011], *Sobotka–Lutz* [2011], *Bongaarts–Sobotka* [2012], *Faragó* [2012], *Berde–Németh* [2014]) that is partly responsible for the drop of the Hungarian TFR, too, which has occurred since the 1980s. However, young women haven't completely forgone childbirth (*Spéder* [2006], *Spéder–Kamarás* [2008], *Pongrácz* [2011], *Szalma* [2011], *Kapitány–Spéder* [2012], *Kamarás* [2012]), at older ages at least some of them try to realize their childbearing intentions, causing some increase in the TFR (tempo effect).

First *Ryder* [1956], [1964], [1980] drew attention to the tempo effect in the middle of the last century. Since then several fertility indicators have been constructed to calculate the average number of live-born children per woman with adjustment for tempo effect (*Bongaarts–Feeney* [1998], [2004], [2006]; *Kohler–Ortega* [2002], *Yamaguchi–Beppu* [2004]). However, besides tempo effect, the estimation of fertility using cross-section data to determine the fertility behaviour of

[1] TFR: total fertility rate.

[2] The tempo effect is a tempo distortion in the value of TFR because of the change in the period mean age of the women at childbearing (*Bongaarts–Sobotka* [2012]).

females over their whole reproductive age span has other pitfalls, too. These drawbacks depend on the changes in data structure and its variation over time. The newest fertility indicators not only correct the tempo effect but also pay attention to the parity composition of the female population (*Kohler–Ortega* [2002]; *Bongaarts–Feeney* [2004], [2006]; *Yamaguchi–Beppu* [2004]).

The various fertility indicators give different pictures about a country's fertility trend. The difference between them may be up to 40 percent or more. (See *Berde–Németh* [2014] Figure 6.) Thus, it is hard to decide which fertility indicator would serve best. By comparing the CFR[3] with the calculated period fertility rates, we may obtain an estimate of these measures' performance.

Besides studying the methodological issues in the context of various fertility rates, the focus of this paper is on the description of the Hungarian fertility trend. It is analysed by comparing the fertility series of Hungary to those of the Czech Republic and Slovakia, because the history and economy of these Central-European countries – which are all members of the so-called "Visegrád" Group[4] – are very similar. We reveal that fertility indicators calculated by using different methodologies and the CFR vary analogously in the three countries. The time series of fertility rates indicate that in the last two decades fertility declined in each of the three countries, and the situation is the most critical in Hungary. However, even the lowest Hungarian adjusted fertility values are higher than the traditional TFR.

Our paper consists of three parts. First, we compare the Czech, Hungarian and Slovak fertility trends using TFR, TFRp*[5] and PATFR*[6] [2002]. It is also demonstrated that the differences between the three main fertility indicators are similar in each country, except for the very beginning of the period observed. Second, we analyse the relationship of the completed cohort and the two corrected fertility rates. Finally, we draw conclusions and identify the areas requiring further research.

1. Hungarian, Czech and Slovak fertility trends from the 1970s

The Czech Republic, Hungary and Slovakia have many similarities not only in their history and development (*Matysiak* [2011]) but also in their fertility trends (*Sobotka*

[3] CFR: completed cohort fertility rate. It shows the average number of children given birth to by women of a cohort during their reproductive life course. The measure can only be calculated when the women in the cohort finish their fertile life.

[4] Due to the lack of data, Poland, the fourth Visegrád country was excluded from the analysis.

[5] TFRp*: tempo- and parity-adjusted fertility rate (*Bongaarts–Feeney* [2004], [2006]).

[6] PATFR*: parity- and age-adjusted fertility rate (*Kohler–Ortega* [2002]).

[2003a], *Goldstein–Sobotka–Jasilioniene* [2009], *Berde–Németh* [2014]). Figure 1 shows three fertility rates (TFR, PATFR*, TFRp*), the MAB[7] and its change[8] for the 1970–2011 period. (For PATFR* and TFRp* figures, see Appendix 1.)

As the upper graphs of Figure 1 show, in the beginning of the 1970–2011 period (except for a few years) the TFR had the highest values among the three indices in each of the three countries. Then the Hungarian, Czech and Slovak TFRs dropped below the two adjusted period fertility rates in 1981, 1983, 1986 respectively and (except for the 1990 Slovak data) remained the lowest. In each country the PATFR* and TFRp* curves approached each other over the whole period.

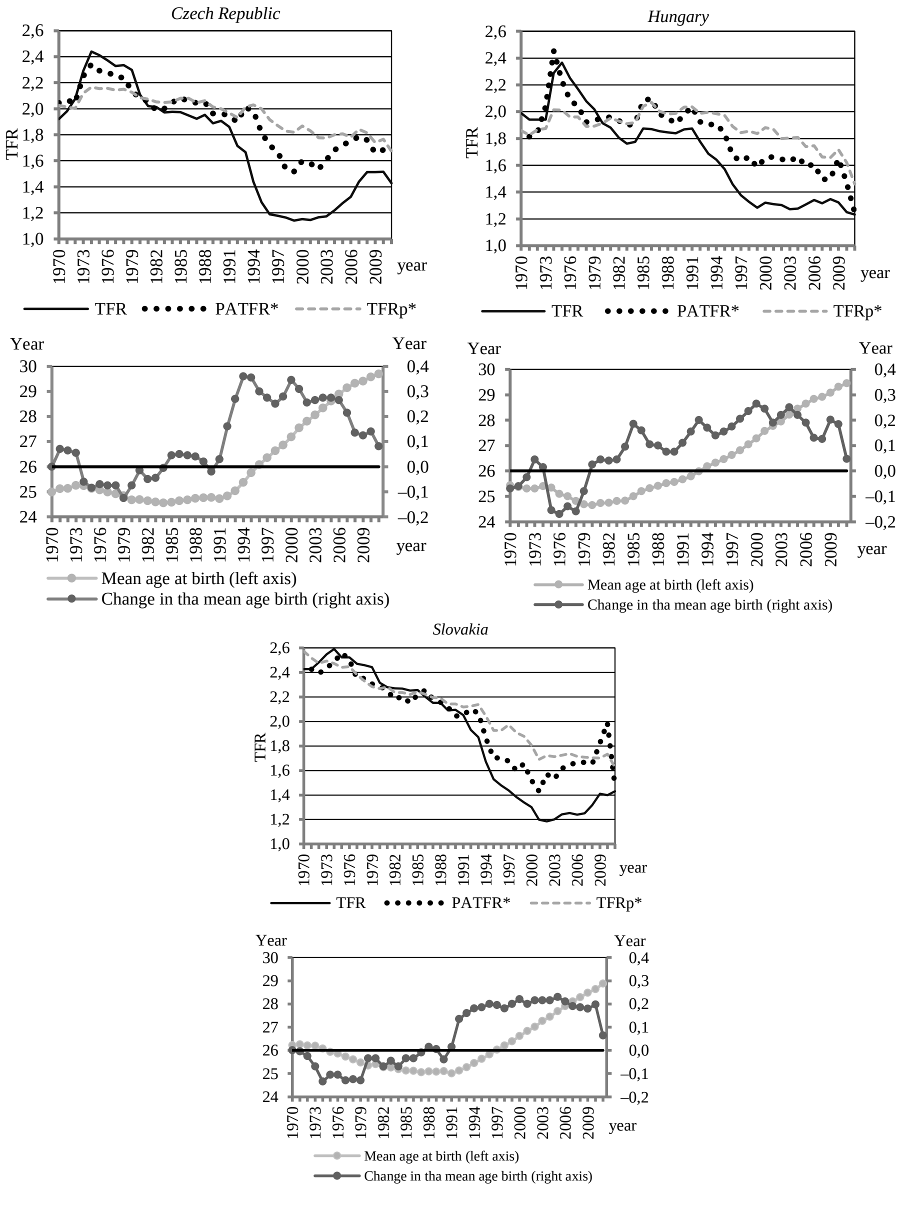
The lower graphs of Figure 1 illustrate that the MAB began to increase in/around that year, when the curve of the TFR fell below that of the TFRp* and PATFR*. This suggests that the decline in TFR was not only caused by the definite decrease in the number of children but also by the postponed childbearing of mothers. Since *Ryder* [1956] first dealt with the postponement of childbearing, this phenomenon has become one of the most often analysed topics in literature (*Bongaarts–Feeney* [1998], *Kohler–Philipov* [2001], *Kohler–Billari–Ortega* [2002], *Ortega–Kohler* [2002], *Sobotka* [2004a], *Husz* [2006], *Goldstein–Sobotka–Jasilioniene* [2009], *Frejka et al*. [2011], *Sobotka–Lutz* [2011], *Bongaarts–Sobotka* [2012], *Myrskylä–Goldstein–Yenhsin* [2013], *Berde–Németh* [2014]). The crucial role of the MAB in Hungary is addressed by one of the studies of *Berde–Németh* [2014], where the estimated linear regression between the increase of the MAB and the TFR for the first parity has yielded a very high multiple correlation coefficient ($R^2 = 0.745$). Strong linear regression was also shown by *Bongaarts–Sobotka* [2012] for the Czech Republic between 1970 and 2008.

If we analyse the connection between the TFRp* and PATFR*, we can see that the latter is higher than the TFRp* in (most) years when the TFR is the greatest among the three period fertility indicators – with a few exceptions, as we have already mentioned. Its explanation may be found in the way the PATFR* is constructed. If the PATFR* has a low (high) value for a certain parity, it stays low (high) for the next parity too, because in the fertility table only those women can bear a second child, who have already born their first, and those who have born the second can have the third, and so on. On the contrary, TFRp* values for different parities are more independent from each other, because the TFRp* relates, for example, the number of second children to all women without two children (i.e. with no child or with one child) in a given age group, and so on. Due to this method, biases in the "same direction" are not cumulated.

[7] MAB: the mean age of women at birth.

[8] The change of the MAB in a given year is the difference between the subsequent year's MAB and the previous year's MAB divided by two (*Bongaarts–Feeney* [1998]).

Figure 1. TFR, PATFR, TFRp* (upper graphs), MAB and its change (lower graphs) in the Czech Republic, Hungary and Slovakia, 1970–2011*



Source: Here and hereinafter, raw data were obtained from the *Human Fertility Database* [2014] with the exception of 2011 Czech data, (*Czech Statistical Office* [2013]), 2010–2011 Hungarian data (*Hungarian Statistical Office* [2010], [2011], [2012]) and 2010–2011 Slovak data (*Statistical Office of the Slovak Republic* [2010], [2011], [2012]). The adjusted fertility rates are our own calculation based on the methodology described by *Jasilione et al*. [2012].

Each fertility indicator shall give an answer to the following question: How many babies are expected on average from a woman of reproductive age over her entire life course? Based on Figure 1, the answer, with respect to the three countries, is: in the 2000s fewer and fewer babies. The relative decrease in the Czech Republic was slightly smaller than in the other two, and at the end of the period analysed the steepest decline was experienced in Hungary. Since 1995, the values of the countries' two tempo- and parity-adjusted indicators have been below 2.1 regarded as the replacement fertility level in modern market economies (*Chesnais* [2000], *Sobotka* [2004b]).

The consequences of the delayed economic crisis in the 2000s could be one of the reasons for the fertility rates decrease (*Bongaarts–Sobotka* [2012], *VID* [2012], *Goldstein et al*. [2013], *Berde–Németh* [2014]), but it is evident that the tendency of MAB changes had to be among the causes, too. (See Figure 1.) At the end of the period, increase of the MAB slowed down, probably because women, owing to their postponing behaviour, almost reached the end of their reproductive life course. Thus, they can/could no longer delay their parenthood if they have/had wished to give life to more than one child. Further research is needed to explain the situation, but the fact is evident: the hope for the positive change in fertility trends is completely vain in the three countries. The slight increase in the TFR experienced in the previous decade is a result of the slowing postponement of childbirths, and does not mean real increase in the number of children women have during their life. Therefore, politicians should continue to be preoccupied with the decreasing size of the populations.

The adjusted period fertility indicators show the real fertility quantum more accurately than the traditional TFR. But how much more? In addition, which of the two tempo- and parity-adjusted total fertility rates performs better? Hindsight, after the reproductive lifespan of women, of course, we can find out the value of CFR in countries where the statistical recording of population fertility is well developed. (See *Human Fertility Database* [2014].) Still, it is not easy to answer the former questions because we have to decide which fertility measures will be compared; and the method of evaluation raises some problems, too. In the next chapter, however, we recommend a method to provide answers and compare CFRs with the tempo- and parity-adjusted period fertility indicators.

2. Difference between various fertility rates

When women of a cohort finish their fertile life – presuming the country has accurate fertility records[9] –, we can calculate the "real" fertility rate of that cohort, i.e. CFR. This indicator, however, does not help policy-makers introduce the best measures to increase (or decrease) the number of children to be born, because at the time of its construction it is already too late to intervene. The CFR describes what happened in the past but cannot indicate what to do, and the benefits from its usage in modelling future developments by different scenarios are limited. However, it provides indirect help in describing and evaluating the actual situation. If we compare the CFR with period fertility indicators calculated upon cross-sectional data of a given year, we can conclude which period fertility must be used to get the closest value to the real fertility rate.

In times when there are not any significant changes in the structure of the female population – regarding different features of childbearing, such as parity, age of mothers, mortality, migration, etc. –, the TFR and the two parity- and tempo-adjusted period fertility rates predict accurately the average number of children a mother would have. However, when something changes in the structural composition, the undistorted fertility rate must be controlled for this change as TFRp* and PATFR* do. Both of these indicators take into consideration the parity composition of mothers (the number of their children) in the year observed and make corrections for the change in the mean age at birth, i.e. for the tempo effect. The construction of the two adjusted indicators differs (see *Bongaarts–Feeney* [1998] p. 278. Equation /3/ and *Kohler–Philipov* [2001] p. 8. Equation /11/), so their values are not equal. (See Figure 1.) Until the second third of the 1980s, the TFRp* and PATFR* values were quite close to each other in the three countries, and in that relatively "quiet" period, large changes of the MAB were not observed either. (See lower graphs of Figure 1.) Then, in the last third of the 1980s, a steep TFR[10] fall and rise in the MAB were recorded, and the difference between the TFRp* and PATFR* values became larger and larger. The difference began to diminish only from the second half of the 2000s.

To find out which adjusted fertility indicator performs better, we have compared the TFRp* and the PATFR* with the CFR, in accordance with the techniques published in literature (*Bongaarts–Sobotka* [2012], *Sobotka* [2003b], *Caselli–Vallin–Wunsch* [2006], *Myrskylä–Goldstein–Yenhsin* [2013]). Note, however, that all types of total fertility rates hide changes in parity fertility rates, when positive and negative

[9] The *Human Fertility Database* [2014] contains suitable Czech and Slovak data from 1935 and Hungarian figures from 1937.

[10] Compared to Western European countries, this late, accelerated decrease in TFR was experienced in many other former communist countries, too, such as Estonia, Latvia, Lithuania, Poland, Russia, Slovenia, and Ukraine (*Eurostat* [2014], *Goldstein–Sobotka–Jasilioniene* [2009]).

differences level each other off and disguise some important changes in the fertility behaviour of women. To sidestep this contradiction, it is worth using parity fertility rates whose sum equals the TFR. Our methods can be illustrated by the example of the female cohort born in 1955. In Hungary, the mean age of women belonging to this cohort was 22.63 at the birth of their first child (*Human Fertility Database* [2014]). We can examine the differences between their first-parity CFR and period fertility rates from 1978 (given by rounding 1955+22.63≈1978). For the comparison, we should find a cohort for every year for which the mean age at birth of the first child is equal to that certain year. However, some years may exist, when no such cohort can be found. In these cases, we average the first-parity CFRs of the previous and next years.

We have carried out this comparison only for the first, second and third birth orders because higher orders represent only a negligible part of the fertility rates in each of the three countries (*Goldstein–Sobotka–Jasilioniene* [2009], *Kapitány–Spéder* [2012]). The comparison can be performed until the year for which we have the latest CFR for the first parity. For example, if we want to calculate the fertility rate for 2003 and assume that the cohort who obtained the MAB for the first birth order in 2003 was born in 1973, we should wait until 2023, because the end of women's reproductive life is 50 years of age in current statistics.

If only the second- and third-parity CFRs are taken into account, and the cohort that obtained the MAB for the second birth order in 2003 was estimated to be born in 1970, we should wait until 2020 to find out real data. (This means three years less compared to 2023.) The "good news" is that due to their calculation methods, there are only small differences between the first-parity PATFR* and TFRp*. (See Table 1.) Therefore, only the comparison of second- and third-parity indicators could give an accurate picture as to which type of fertility rates performs better.

Moreover, if we are interested in the number of births given by women under 40 (the age until almost all births are given), the waiting period can be further reduced. (To find out real data, for example, in the case of the second births of the previous example, we should have only waited until 2010.) Unfortunately collecting and elaborating data take time, which also extends slightly the waiting period.

First we have made a comparison for the relatively quiet period of 1978–1987, when the MAB remained comparatively stable, neither significant increase nor decrease occurred, and no great differences were found between PATFR* and TFRp* values. (See Figure 1.) Since there were only small differences between the three countries in their same-parity MABs, we used slightly different cohorts for each of them.[11] Since the values of the period fertility indicators in a single year

[11] First parity: the Czech Republic – 1956–1965 cohort; Hungary and Slovakia – 1955–1964 cohort. Second parity: Hungary – 1952–1961 cohort; the Czech Republic and Slovakia – 1953–1962 cohort. Third parity: Czech Republic and Slovakia – 1950–1959 cohort, Hungary 1949–1958 cohort.

depend greatly on occasional events, to exclude uncertainty, we have calculated a five-year moving average for the TFRp* and PATFR*. (A similar method of excluding random noise was used by *Bongaarts–Sobotka* [2012], too.) Table 1 shows the results of comparison and Figure 2 presents the graphs of the three indicators.

Table 1

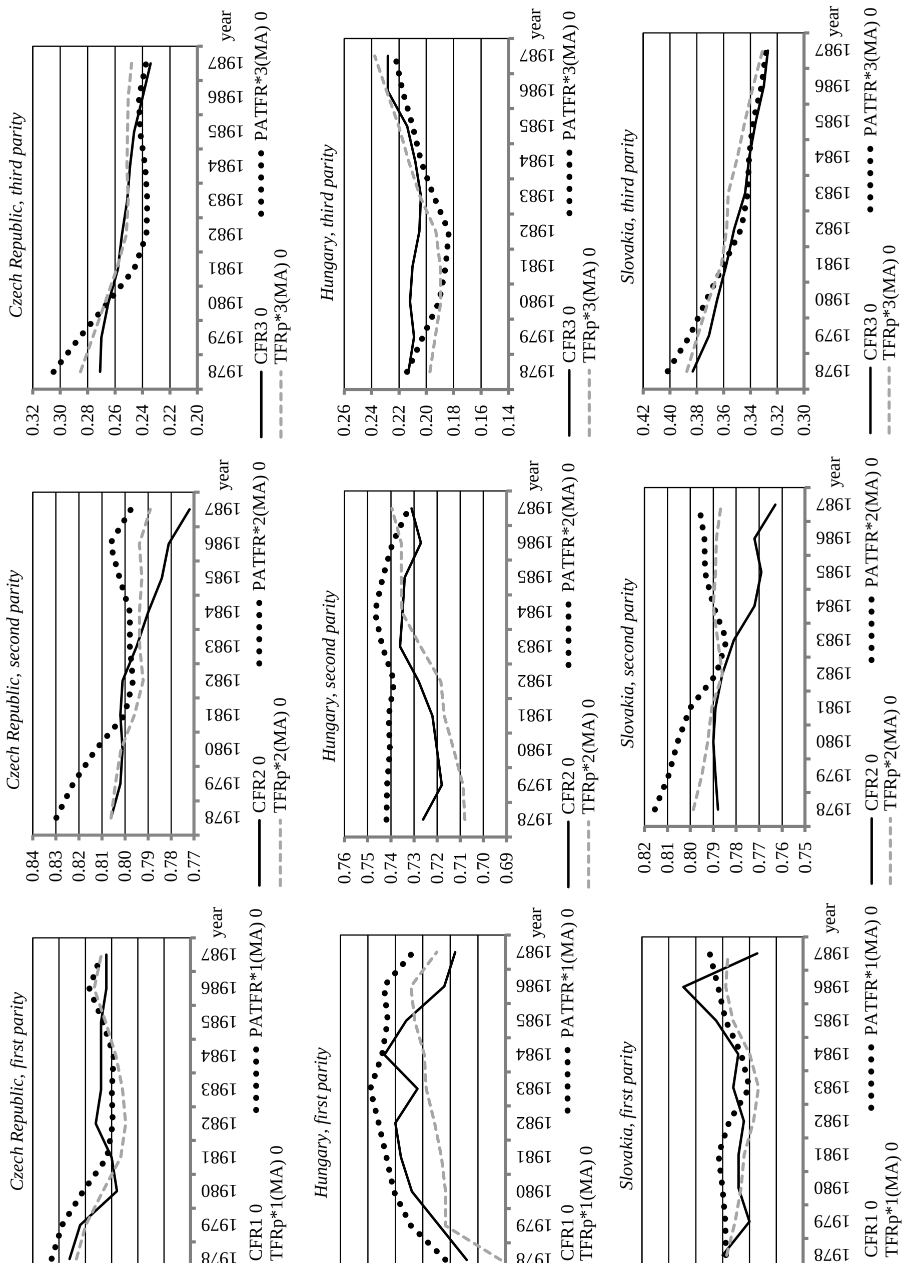
Averages of the absolute values of differences between CFR and PATFR and between CFR and TFRp* by parity, 1978–1987*

Country/Average	Difference	First parity	Second parity	Third parity
Czech Republic	CFR – PATFR*(MA)	0.002634	0.014209	0.011643
	CFR – TFRp*(MA)	0.002354	0.006138	0.005925
Hungary	CFR – PATFR*(MA)	0.005154	0.013206	0.010781
	CFR – TFRp*(MA)	0.004379	0.007687	0.010775
Slovakia	CFR – PATFR*(MA)	0.004837	0.017752	0.005480
	CFR – TFRp*(MA)	0.003879	0.010610	0.006977
Average of per-country differences	CFR – PATFR*(MA)	0.004208	0.015056	0.009301
	CFR – TFRp*(MA)	0.003537	0.008145	0.007892

Note. Here and hereinafter, MA stands for moving average.

According to Table 1, the differences between CFR and TFRp* are smaller than between CFR and PATFR* for every parity. This means that in peaceful times, when there are not big changes in fertility trends (as the 1978–1987 period was in the three countries), the Boongarts–Feeney tempo- and parity-adjusted period fertility rate (TFRp*) performs better than the Kohler–Ortega indicator (PATFR*). Again, it is worthy to note that the differences for the second and third parities are greater than the differences for the first parity because TFRp* and PATFR* values for various birth orders are added together. Thus, these total period fertility indicators are very sensitive to the components of the second and third birth orders. Table 1 also illustrates that the PATFR* is less reliable than the TFRp*. The great sensitivity of the PATFR* may be due to how it is constructed: fertility tables inherit biases from lower to higher parities. On the contrary, calculation of the TFRp* for a higher birth order does not rely on the results of the lower one(s), so previous errors are not passed on.

Figure 2. PATFR, TFRP* and CFR by parity, 1978–1987*



The accuracy of period fertility indicators is much crucial in periods when the fertility trend and the structure of the female population are changing (for example, when childbearing is postponed compared to stable periods), as it was the case between 1993 and 1997 in the three countries. (Although the change was intense between 1988 and 1992, it did not reach the level of 1993–1997.) After 1997 the transition continued. CFR values, however, do not exist for this late period (neither for the first parity from 1993 to 1997 nor for the whole reproductive period of women regarding the second and third birth orders). Therefore, we could have used the CFR for the second and third birth orders taking the latest available year into consideration (just like *Boongarts–Sobotka* [2012]) and substituted the missing cohort fertility data of an older age group with the actual period fertility rates of the same age group. Instead, we have used the CFR and calculated the PATFR* and TFRp* until 40 years of age. In some cases, it was impossible to find a cohort whose MAB for the second and third children belonged to the 1993–1997 period. In these cases, the average CFR40 of the two adjacent cohorts were taken, the MAB of which was just before and after the relevant year.

Table 2 presents the results of the comparison, and Figure 3 shows the trends of the three indicators.

Table 2

*Averages of the absolute values of differences between CFR40 and PATFR*40 and between CFR40 and TFRp*40 by the second and third parities, 1993–1997*

Country/Average	Difference	Second parity	Third parity
Czech Republic	CFR40 – PATFR*40(MA)	0.038392	0.051421
	CFR40 – TFRp*40(MA)	0.037999	0.014328
Hungary	CFR40 – PATFR*40(MA)	0.038559	0.060083
	CFR40 – TFRp*40(MA)	0.017378	0.006381
Slovakia	CFR40 – PATFR*40(MA)	0.031766	0.063525
	CFR40 – TFRp*40(MA)	0.003918	0.016633
Average of per-country differences	CFR40 – PATFR*40(MA)	0.036239	0.058343
	CFR40 – TFRp*40(MA)	0.019765	0.012447

Note. 40: only data of 40-year-old and younger women are taken into consideration.

*Figure 3. CFR40, PATFR*40, and TFRp*40 by parity, 1993–1997*

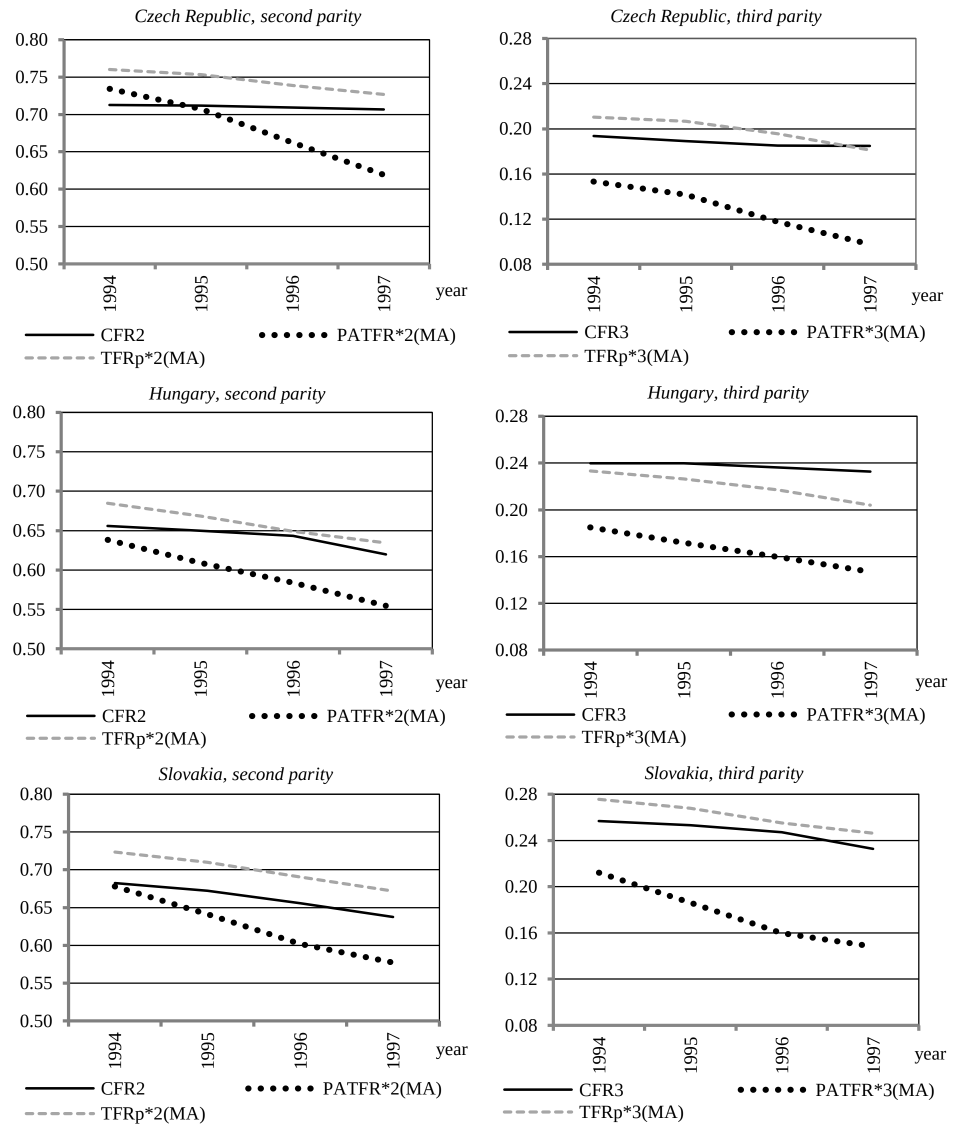
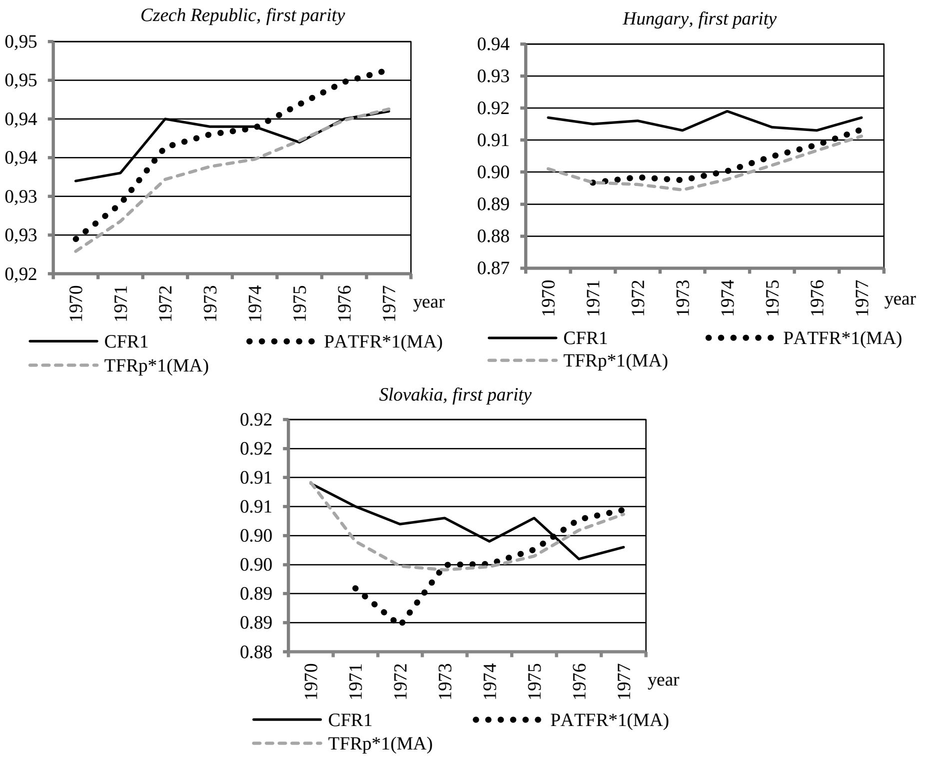


Table 2 and Figure 3 illustrate that the TFRP*40 for both the second and third birth orders is closer to the CFR40 than the PATFR*40 in each country. The average of the differences of the CFR40 and TFRp*40 is about 55% of that of the CFR40 and PATFR*40 as for the second parity, and only about 20% regarding the third parity. The results reveal that the TFRp* performs generally better than the PATFR*. (See

Tables 1 and 2.) However, the differences in Table 2 are greater than in Table 1, which refers to the fact that the TFRp* cannot indicate the exact fertility rate either when the structure of the female population changes. Therefore, further research is needed to discover what corrections should be made to improve the accuracy of these fertility indicators.

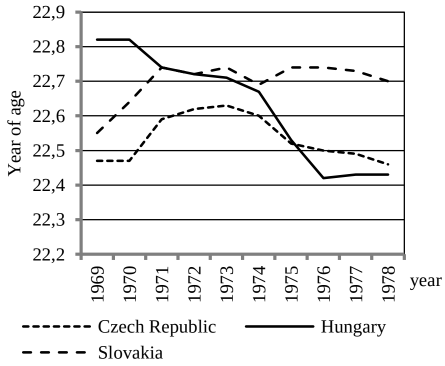
Based on the aforementioned, one may think that the TFRp* always performs better than the PATFR*. To demonstrate that the assumption is not always true, we have also examined the 1970–1977 period (when the MAB was decreasing (with a few exceptions)), and calculated the CFR by the same method used previously. The findings are controversial. (See Figure 4.)

Figure 4. CFR, PATFR and TFRp* by first parity, 1970–1977*



In the 1970–1977 period the PATFR* performed better than the TFRp* for the first parity both in the Czech Republic and Hungary, but in Slovakia the TFRp* had the best results. These findings can be explained by the mean age of women at the birth of their first child. (See Figure 5.)

Figure 5. Mean age of women at the birth of their first child, 1969–1978



In Figure 5, the MAB shows a continuously decreasing trend for Hungary, first rises then falls in the Czech Republic, and after an initial increase remains almost constant in Slovakia. Changes in the MAB have a crucial role in the correction factor of both adjusted period fertility rates. Generally, if the MAB grows, the original fertility number is increased by correction, whereas a falling MAB lowers the corrected fertility rate, too. The correction in the case of the PATFR* depends on the age of mothers and the standard deviation of the childbearing age, but as for the TFRp*, the correction factor is the same for all ages. When the MAB rises, the factor helps to reveal the real fertility rate of younger generations and does not have a strong effect on the older one(s), where fertility numbers are low. However, when the MAB falls, the TFRp*value for younger generations is distorted due to correction, which is either negligible or can raise the value of the indicator in the case of the PATFR*. According to our results, when the MAB increases, the TFRp* performs better, but when it decreases, the PATFR* is more convenient at least for the first parity. Table 3 shows, however, that these conclusions are disputable in the cases of higher birth orders. Despite the fact that the MAB values for the second and third births have very similar tendencies to those for the first birth, the TFRp* gives better results in each of the three countries for the second and third parities.

Table 3

Averages of the absolute values of differences between CFR and PATFR and between CFR and TFRp* by parity, 1970–1977*

Country/Average	Difference	First parity	Second parity	Third parity
Czech Republic	CFR – PATFR*(MA)	0.003918	0.020410	0.054809
	CFR – TFRp*(MA)	0.004147	0.012946	0.022726
Hungary	CFR – PATFR*(MA)	0.012500	0.029060	0.049782
	CFR – TFRp*(MA)	0.014559	0.018155	0.017444
Slovakia	CFR – PATFR*(MA)	0.008869	0.018897	0.024957
	CFR – TFRp*(MA)	0.006231	0.007261	0.01509
Average of per-country differences	CFR – PATFR*(MA)	0.008429	0.022789	0.043183
	CFR – TFRp*(MA)	0.008312	0.012787	0.018420

As our results show, there is not a straightforward rule to determine which of the two tempo- and parity-adjusted period indicators performs better under all circumstances. Table 4 summarizes the strengths, weaknesses, opportunities and threats of these measures given by SWOT analysis, a widely used tool in economics.

Table 4

SWOT analysis of the two tempo- and parity-adjusted fertility indicators

Strengths	Weaknesses	Opportunities	Threats
TFRp*			
It is more precise than the PATFR* when childbearing is postponed.	It can show a false picture when the MAB decreases.	Its performance could be improved by incorporating the mothers' age into the correction factor.	It is not correct if the postponement of childbearing is reversed.
PATFR*			
In addition to MAB correction, it also depends on the mothers' age and the standard deviation of childbearing age.	The calculation-related bias regarding a certain parity is passed onto higher birth orders.	It can be used instead of the TFRp* when the MAB continuously decreases.	The fertility table brings too much rigidity into calculation.

In spite of the drawbacks included in Table 4, we still recommend the usage of these adjusted fertility indicators (instead of the TFR) when large changes in the structure of the female population occur. In the periods of childbearing postponement, especially the TFRp* is useful. Nevertheless, when the MAB is steadily declining (what rarely happens nowadays), further investigation is needed before choosing the calculation method of period fertility rates.

3. Conclusions

In this paper, we have analysed the fertility trends in three adjacent Central-European countries (the Czech Republic, Hungary and Slovakia) between 1970 and 2011. These countries have a similar history, thus, it is not surprising that they are much alike regarding the number of children and the women's age at childbirth. The general tendency was the continuous decrease of fertility rates in all three countries, with a few, short, exceptional periods and with a steeper decrease at the very end of the time interval examined.

In the 2000s, only looking at the traditional TFR, some policy-makers recognized mistakenly a reversal or recovery in the fertility trends of the three countries. However, by studying the adjusted fertility rates, we have found that the quantum factor of fertility had further decreased. Contrary to some Western European countries, there is no sign of increasing fertility rates. Still, the fertility trend is not lowering unambiguously as might be thought using only TFRs. Although the postponement of childbearing from the beginning of the first third of the 1980s has accelerated and resulted in the "lowest low" TFR (*Kohler–Billari–Ortega* [2002], *Sobotka* [2004b]), if the whole reproductive period is considered, women still give birth to more children according to the Bongaarts–Feeney TFRp* and Kohler–Ortega PATFR* than the TFR forecasts. Nevertheless, the steep fall of fertility rates at the end of the period analysed may be a signal of radical decrease in childbearing intentions.

In addition to comparing and evaluating the Czech, Hungarian and Slovak fertility behaviour, we have also aimed to judge the performance of various adjusted fertility rates. For both the TFRp* and PATFR*, we have taken into consideration the parity distribution of the female population in the year of observation and control for the expected timing of childbirths, i.e. use tempo correction. After women finished their reproductive period, the observed CFR can be used to find out which of the corrected period fertility indicators performs better. Although the CFR gives information on fertility "relatively late", it still proves to be an effective tool for evaluating the accuracy of fertility rates calculated for previous years. We also explained in detail how it can be compared with the TFRp* and PATFR*.

The tempo correction of the PATFR* is more sophisticated and avoids the undervaluation of the fertility rate in times when the MAB decreases. However, this advantage is counterbalanced by frequent errors owing to the way it is constructed. When calculating the PATFR*, we use fertility tables for women, where a distortion in the rate at a certain birth order is passed on to subsequent birth orders, leading to a false result. The TFRp* avoids this problem by treating each parity independently, and in most of the cases it performs better than the PATFR*. Based on the findings, we suggest the general usage of the TFRp*, when the MAB does not show a permanently decreasing trend (which shall be the subject of further consideration). We are intending to continue the research to find a more sophisticated method of correcting the traditional fertility rate.

Appendix

PATFR and TFRp* in the Czech Republic, Hungary and Slovakia, 1970–2011*

Year	PATFR*			TFRp*		
	Czech Republic	Hungary	Slovakia	Czech Republic	Hungary	Slovakia
1970	2.046	1.839	2.474	2.026	1.860	2.574
1971	2.068	1.813	2.427	2.013	1.844	2.518
1972	2.041	1.846	2.393	2.001	1.867	2.475
1973	2.259	2.038	2.435	2.120	1.893	2.494
1974	2.363	2.454	2.485	2.167	2.069	2.474
1975	2.305	2.232	2.559	2.154	2.066	2.441
1976	2.279	2.085	2.505	2.158	1.996	2.447
1977	2.234	2.041	2.353	2.144	1.961	2.381
1978	2.243	1.922	2.350	2.151	1.890	2.330
1979	2.142	1.935	2.305	2.126	1.892	2.284
1980	2.079	1.952	2.290	2.086	1.914	2.268
1981	2.053	1.960	2.249	2.074	1.952	2.281
1982	1.986	1.933	2.181	2.054	1.929	2.236
1983	2.001	1.898	2.206	2.049	1.910	2.237
1984	2.049	1.911	2.152	2.053	1.919	2.220
1985	2.084	2.085	2.218	2.080	2.040	2.242
1986	2.057	2.096	2.255	2.080	2.069	2.224
1987	2.044	1.983	2.185	2.047	2.004	2.195

(Continued on the next page.)

(Continuation.)

Year	PATFR*			TFRp*		
	Czech Republic	Hungary	Slovakia	Czech Republic	Hungary	Slovakia
1988	2.050	1.954	2.158	2.061	1.983	2.191
1989	1.963	1.911	2.114	2.014	1.988	2.142
1990	1.967	1.978	2.044	2.001	2.034	2.143
1991	1.945	2.037	2.052	1.967	2.037	2.117
1992	1.900	1.924	2.101	1.932	1.988	2.125
1993	2.013	1.903	2.068	2.013	1.996	2.137
1994	1.980	1.910	1.861	2.029	1.986	2.044
1995	1.814	1.838	1.703	2.001	1.972	1.926
1996	1.719	1.670	1.703	1.915	1.891	1.927
1997	1.666	1.632	1.675	1.870	1.844	1.973
1998	1.533	1.664	1.600	1.828	1.855	1.909
1999	1.517	1.585	1.655	1.819	1.837	1.879
2000	1.599	1.656	1.518	1.869	1.880	1.806
2001	1.581	1.663	1.430	1.831	1.868	1.690
2002	1.532	1.645	1.571	1.776	1.800	1.722
2003	1.610	1.630	1.530	1.774	1.804	1.714
2004	1.683	1.664	1.617	1.801	1.808	1.725
2005	1.723	1.591	1.645	1.807	1.740	1.739
2006	1.752	1.607	1.667	1.782	1.747	1.715
2007	1.788	1.494	1.666	1.842	1.661	1.709
2008	1.760	1.498	1.656	1.815	1.658	1.704
2009	1.663	1.650	1.822	1.739	1.718	1.702
2010	1.684	1.470	1.989	1.767	1.620	1.734
2011	1.682	1.243	1.461	1.673	1.461	1.626

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LeadING HUBE: An Effective Leading Indicator for the Performance of the Hungarian Business Sector

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In this study a new leading indicator called LeadING HUBE (LeadING Index for the Hungarian Business Economy) is introduced and being calculated on a monthly basis to show the expected trajectory of the output of the private sector (as a proxy of added value) with significant lead and certainty. The authors' aim was to create an indicator which may be used for both policy and business purposes. They present the construction of LeadING HUBE and compare its performance with other, freely accessible leading indicators, demonstrating that this newly developed index outperforms them when it comes to lead time and reliability. Thus, LeadING HUBE does not only add to the extensive literature on leading indicators but also supplements it.

Keywords:
Business sector.
Indicator.
Forecast.

Although it is very important for the economic actors (decision makers, traders, analysts, etc.) to get a clear and prompt picture about the current state and future prospects of the economy, statistical "hard" data, such as GDP, are released with a significant delay. Thus, economists need to monitor other hard and soft indicators too, in order to gain information about the actual business situation and the expected path of the economic activity. A number of variables have some predictive power on the latter, but composite indices often perform quite adversely on a day-by-day forecast basis. In some cases, they contradict each other, making it difficult to derive any clear message from analysis.

In response to this recurrent issue, the main goal of this paper is to develop and present a new composite leading indicator of the Hungarian business economy; one that is constructed to predict business cycles on a monthly basis, in a reference series chosen as a proxy for economic activity. It is called LeadING HUBE (Leading Indicator for the Hungarian Business Economy).

In the construction of such a leading indicator, it is crucial to get early signals of the turning points in economic activity. These signals need to be reliable and minimise the number of false alarms. Besides, the index should be available on a monthly basis in order to offer forecasts regularly for forthcoming periods. It is also assumed that its significant monthly variation and huge ex post revisions are undesirable and thus should be avoided.

After this introduction, the structure of the paper is as follows: in Section 1, the theoretical background of business cycles and the creation of composite leading indicators are presented. Section 2 first summarises the construction of LeadING HUBE along with data issues and transformation of the time series, etc. Then, after giving a detailed demonstration of the index, it compares its performance in recession signalling with that of the OECD[1] leading indicator, SZIGMA[2] and GYIA[3] of ECOSTAT[4].

1. Construction of leading indicators

In the following subsections, we outline the usual way of creating a leading or coincident indicator, relying heavily on *Marcellino*'s [2006] work. First, we investigate

[1] OECD: Organisation for Economic Co-operation and Development.

[2] SZIGMA (Századvég index a gazdasági momentum alakulásáról): index of the "Századvég" Economic Research Institute on the actual state of the economy.

[3] GYIA (gyorsulási irányadó): acceleration index.

[4] ECOSTAT: Institute for Economy and Society Research.

the problems related to choosing a reliable reference series that is calculated on a monthly basis and represents properly the actual phase and dynamics of the business cycle. Then we sketch up two possible groupings of economic variables, which have proved useful in our research. Filtering, data handling and methods of constructing leading indicators are addressed only marginally.

1.1. Choice of reference series

Composite leading indicators aim to signal the performance of an economy and its turning points, hence ultimately trying to predict the future state of the business cycle. The question is how economic performance can be measured. Not surprisingly, the most widely used variable providing a prompt picture of the economic activity (despite its drawbacks) is GDP[5] calculated by national statistical offices. The problem is in that case that GDP is only available on a quarterly basis and with a delay, since its first (flash) estimate for the Hungarian economy is released 45 days after the end of the actual quarter. There are two options to overcome this problem: *1*. transformation of quarterly GDP figures to monthly frequencies (e.g. through interpolation), *2*. choosing or constructing an artificial reference series. In this study, the second approach is followed, therefore, transformation of GDP figures will not be discussed.

It is important that the chosen reference series is produced at a monthly frequency and correlates strongly with GDP. The most popular choice used to be IP[6] in the past few decades, since it met the earlier mentioned requirements. However, due to the changing structure of the economy and the diminishing importance of the sector in developed countries, its correlation with GDP has weakened and the construction of more sophisticated variables has become widespread.

1.2. Groups of variables

In our study, we define three different groups of soft and hard economic variables differentiated on the basis of their relation to business cycles (for more details see *Williamson* [2009]):

– *Acyclical variables'* cyclical movements are independent from the business cycles.

[5] GDP: gross domestic product.
[6] IP: index of industrial production.

– *Procyclical variables* (just like consumption, number of employed persons, level of industrial production, inflation, etc.) have positive correlation with GDP.

– *Anticyclical variables* (e.g. unemployment rate) correlate negatively with GDP.

Acyclical variables are not taken into consideration when a composite leading indicator is created, since they do not contain any information regarding the present or the future value of the reference series. On the contrary, procyclical and anticyclical variables are both useful and possibly worth taken in our leading indicator. (Note that anticyclical variables should be added to the index with a negative sign.)

Another grouping of potential variables showing either strong procyclical/anticyclical correlation with GDP or other reference series takes into account the timing of comovements. According to this categorization, three different groups can be identified: coincident, leading and lagging variables. Leading variables precede the business cycles, while coincident variables either move firmly together with or come shortly before them. Lagging indicators follow the path of the cyclical movements of GDP and as such, contain no relevant information for the construction of a leading index.

1.3. Filtering and data handling

After obtaining a suitable reference series and leading variables, the next step is data transformation. First, given a raw time series including both irrational and seasonal components, the exclusion of high frequency noise and outliers is necessary. After seasonal adjustment of the series, the type of transformation must be chosen. Macroeconomic and financial variables can be described by unit root processes, thus variance is an increasing function of time, while the expected value is non-constant of the time series. These may lead to spurious regression and wrong inference; therefore, the transformation of both leading (explanatory) variables and reference series (dependent variable) is required in order to include them "statistically properly" in the econometric models.[7] The transformation determines the nature of the analysed business cycles. The so-called "classical cycle" refers to fluctuations in the economic activity level (e.g. measured by GDP in volume terms or fluctuations in the output gap), while the "growth cycle" denotes fluctuations in the economic growth around the long-run potential level. Growth cycles may be defined as the difference between the actual growth rate and trend growth (or potential growth). In other words, the

[7] Due to the business cycle focus of the index, we do not deal with the cointegration of variables.

differences of the natural logarithms of the time series are taken to obtain percentage changes of variables, and then the historical average of the series is subtracted. Contrarily, the focus of analysis is the cyclical fluctuations of the level of variables in the case of classical cycles.

1.4. Methods of the construction of composite leading indicators

When creating composite leading indicators, the main aim is to combine and unite information being present in different leading variables in order to get a single index that efficiently predicts the path of GDP. According to *Marcellino* [2006], such a constructed index should have the following features. It

– gives consistent and accurate signals of the turning points of GDP along with steady lead time;
– follows firmly the trajectory of GDP between turning points;
– is based on reliable statistical background;
– is economically interpretable;
– is responding quickly and significantly to both negative and positive impulses;
– can be released regularly and quickly after the actual month/quarter while revisions of previous values are minimal;
– has no large monthly variability, in other words, its "noise" is limited.

In his study, *Marcellino* [2006] reviewed the widely applied methods of construction and differentiated between model-based and non-model-based indices. In the latter group, filtering, transformation and standardisation of time series are followed by a weighting scheme (e.g. coincident indicator of *The Conference Board* [2001]). Model-based indicators may be categorized as either factor models described by *Stock–Watson* [1989] or indicators that are built on Markov models (*Hamilton* [1989]).

2. Creation of LeadING HUBE

In the following subsections, the process of LeadING HUBE development is summarised. First, we introduce our monthly coincident variable and then investigate a large set of potential leading variables.

2.1. Coincident index

As it was mentioned earlier, GDP would be a natural choice as a reference series, but official statistics are released only quarterly, while LeadING HUBE is calculated on a monthly basis. Therefore, it is needed to construct a new reference series or coincident variable that can be derived from official monthly statistics and correlates significantly with GDP.

This coincident variable is determined by the volume of retail sales (denoted by *ret_turn*) (as a proxy for services) and that of production in both the industrial (*ind_prod*) and construction sectors (*con_prod*). Since these variables are available on a monthly basis, it is not necessary to attempt to interpolate GDP, which would raise a number of concerns regarding accuracy and statistical correctness. The first step is to transform the variables to exclude high frequency noise, outliers and seasonal patterns, hence enabling LeadING HUBE to concentrate on the proper periodicities of the time series. In this study the Henderson filter is applied that is derived by minimizing the sum of squares of the third difference of the moving average series (*Henderson* [1916]). The biggest advantages of this filter are the following: it allows the cycles typical of the trend to pass through unchanged and eliminates all the irregular variations that are of very short frequencies. However, just as in the case of the *Hodrick–Prescott* filter [1997], the standard endpoint problem emerges (*Proietti–Luati* [2008]). It means that in the middle of a time series, filter weights are symmetric, while the end filter weights are asymmetric, leading usually to biasedness in the output around the endpoint.

After seasonally adjusting the series using Census (X12) program and deriving their trend cycles by applying the Henderson filter, regression of the volume of retail sales, industrial production and construction output on GDP follows. The estimated coefficients are used as weights in the construction of the coincident variable (the weighted average of the mentioned time series).

Table 1

Regression model for the construction of the coincident index

Dependent variable	dlog(GDP)
Constant	**0.0013**
	1.3501
dlog(*con_prod*)	**0.0435**
	5.2597
dlog(*ind_prod*)	**0.2378**
	7.5053
dlog(*ret_turn*)	**0.1429**
	5.2616

R-squared value	0.793358	Mean of dependent variable	0.004630
Adjusted *R*-squared value	0.781662	Standard deviation of dependent variable	0.009690
Standard error of regression	0.004528	Akaike info criterion	–7.889474
Sum of squared residuals	0.001087	Schwarz criterion	–7.746102
Log likelihood	228.85000	Hannan-Quinn criterion	–7.833754
F-statistic	67.82756	Durbin-Watson statistic	0.970486
Prob(*F*-statistic)	0.000000	Wald *F*-statistic	71.25278
Prob(Wald *F*-statistic)	0.000000		

Note. Sample period: 1st quarter 2000–1st quarter 2014; method: ordinary least squares, Newey–West estimation of the variance-covariance matrix of the coefficients. Estimated parameters are in bold; *t*-statistics are in italics.

Source: Here and in all tables and figures (exluding Figure 2) own calculation.

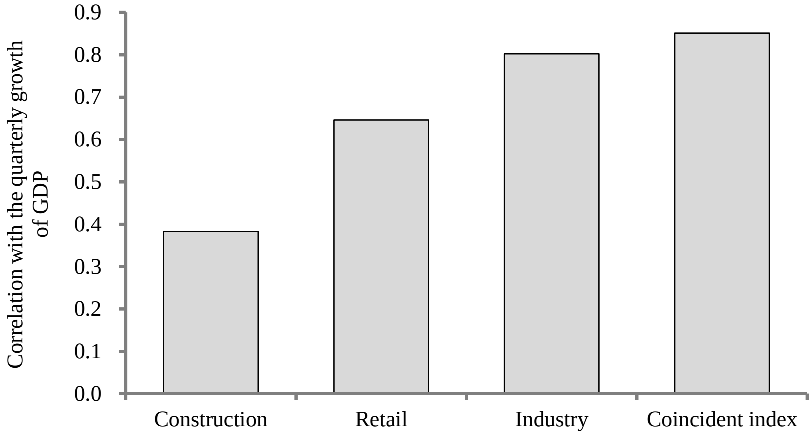
By means of the regression parameters, coincident can be easily calculated. (See equation in /1/.)

$$CI_t = \frac{0.0435 * con\_prod + 0.2378 * ind\_prod + 0.1429 * ret\_turn}{0.0435 + 0.2378 + 0.1429} \qquad /1/$$

where CI stands for the coincident index, while *con_prod, ind_prod* and *ret_turn are* the production of the construction sector, industry and the volume of retail sales, respectively.

Figure 1 demonstrates that the coincident index has the highest correlation with the growth rate of GDP (0.85), outperforming the other variables examined with regard to the strength of comovements.

Figure 1. Correlation between the quarterly growth of GDP and the coincident index along with its components, 2nd quarter 2000–1st quarter 2014



2.2. Variable transformation and selection

In the case of emerging market or transformation economies, it is exceptionally difficult to obtain a reliable estimate of the level of the potential GDP. Therefore, we decided to analyse the growth cycle instead of classical ones. The natural logarithm of the variables and the differences between them were taken in order to get percentage changes. For confidence indicators and consumer and business surveys, only the difference of the variables were calculated without taking the natural logarithms.

In some cases, some additional modifications were implemented. To derive the essence of the expectations of businesses and consumers, the surveys were transformed uniquely. For balance variables, the subtraction of the actual value of a variable at time *t* from its expected value at the same point in time was necessary (i.e. the difference between “Major purchases in the next 12 months” and “Major purchases at present” was calculated). This way, an indicator showing any changes in the consumers’ willingness to make major purchases in the coming months could be captured. Another transformation was that the logarithm of the ratio of two variables (the stock of industrial export orders and industrial production) was taken.

In the construction of LeadING HUBE, it was crucial to find numerous relevant time series that lead the business cycles with steady and sufficient lead time. In our view, finding data that are not subject to significant revisions is just as important as being published on a monthly basis, relatively quickly after a given month ends. Early on in the construction of LeadING HUBE, more than eighty time series were collected and analysed. The data sets included soft and hard data on both the German and Hungarian economies. Hard data encompass financial indicators (exchange rates, interest rates, interest rate spreads, monetary aggregates, indices, etc.), industrial figures (production, sale, stock of orders, etc.), construction sector data (number of employed persons, orders, building permits), retail sales data, labour market figures (number of employed persons, number of registered job seekers, number of part-time workers, etc.), and other financial variables (inflation, budget balance, etc.).

We used cross-correlation analysis to separate the leading, coincident and lagging variables (just like *OECD* [2012] for leading indicators). Cross-correlation measures the strength of the comovement between the reference time series (in our case the coincident index) and the potential leading variables at different leads/lags. Formally:

$$r_i = corr\left(x_t; y_{t-i}\right) \qquad /2/$$

where *r* is the correlation between variables *x* and *y*, when *y* is delayed by *i* months. The peak of the cross-correlation defines whether a time series is a leading, lagging or coincident variable. The variables that showed no correlation with the reference series at any lead or lag ("acyclic variables") were dropped from the further examinations. The remainders were divided into three groups according to the location of the peak in the cross-correlation:

– *leading variables* – positive (for anticyclical variables: negative) cross-correlation reaches its maximum (minimum) between –36 and –11 months ($11 < i < 36$);

– *coincident variables* – positive (for anticyclical variables: negative) cross-correlation reaches its maximum (minimum) between –10 and 0 months ($0 < i < 10$);

– *lagging variables* – positive (for anticyclical variables: negative) cross-correlation reaches its maximum (minimum) in +1 month or later ($i < 0$).

Out of the eighty time series that were originally analysed, only a few proved to be sufficiently significant. Where the cyclical profiles of the variable and the coincident index were highly correlated, the indicator was likely to provide a signal, not only of approaching turning points, but also of developments over the whole cycle. In order to investigate the stability of the set of leading variables and lead times, we repeated our model selection method on two sub-samples. The period of both sub-samples started in January 2000; the first ended in December 2008, while the second in December 2011. Table 2 shows the variables with the longest lead time and with at least 0.2 absolute value of correlation.

The volume of industrial export order book level divided by the volume of industrial production (*ind_ord_sh_ex*) has a very long lead time, and the correlation seems to be also stable. However, its lead time dropped from 28 to 14 months when the sample period was reduced. On the contrary, issued non-residential building permits (*con_bpnh_h*) has a stable lead time and correlation as well. The lead time of the volume of industrial order book level (*ind_ord_h*) is highly uncertain, in the two subsamples the variable acted rather like a lagging variable, thus it was omitted from the model. A few elements of the German and Hungarian households' confidence are stable and good predictors of the business cycle (*cus_pricet_diff_ger*, *cus_majorp_diff_ger*, *cus_majorp_diff_hun*, *cus_save_s_hun_tc*, *cus_mp_s_hun_tc*), while others perform poorly with regard to lead time stability or the strength of comovement. (See Appendix for the explanation of the abbreviations.) The variable "Volume of new orders in construction" (*con_nord_h*) is also a bit unstable, but we assess it as a key variable to the Hungarian business cycle.

Table 2

Cross-correlation between the coincident index and the potential leading variables in different sub-samples

Potential leading variable	Whole sample (ends in June 2014)		Sub-sample whose period ends in December			
			2011		2008	
	Lead time	Correlation coefficient	Lead time	Correlation coefficient	Lead time	Correlation coefficient
ind_ord_sh_ex	–29	0.3119	–28	0.2559	–14	0.3034
con_bpnh_h	–28	0.3675	–28	0.3269	–27	0.3431
ind_ord_h	–28	0.2480	6	0.5739	6	0.4215
cus_pricet_diff_ger	–27	–0.3667	–27	–0.3224	–26	–0.2919
con_nord_h	–27	0.2559	–29	0.2266	0	0.3148
cus_majorp_diff_ger	–26	0.4517	–26	0.5356	–24	0.5482
cus_majorp_diff_hun	–23	0.2876	22	0.3985	–21	0.4223
cus_sav_s_ger	–19	–0.2614	19	–0.2076	–7	–0.2085
cus_save_s_ger	–18	–0.2228		>0.200	–17	–0.2539
cus_pt_s_ger	–13	–0.3141	–14	–0.2412	–6	–0.4005
con_ord_h	–12	0.4193	–12	0.3656	–17	0.3959
cus_pt_s_hun	–12	–0.2621	–24	–0.3683	–7	–0.2632
cus_pte_s_hun	–12	–0.2400		>0.2000	–9	–0.2459
cus_mp_s_hun	–11	0.3863	–29	0.4099	–10	0.3895
cus_save_s_hun	–11	0.2565	–11	0.2034	–11	0.2699
cus_finsite_s_hun	–9	0.2112	–29	0.3242	–24	0.3597

(Continued on the next page.)

(Continuation.)

Potential leading variable	Whole sample (ends in June 2014)		Sub-sample whose period ends in December			
			2011		2008	
	Lead time	Correlation coefficient	Lead time	Correlation coefficient	Lead time	Correlation coefficient
cus_genee_s_hun	–9	0.2734	–29	0.2607	–24	0.2800
cus_mpe_s_hun	–9	0.2222	–28	0.3825	–25	0.4107
cus_gene_s_hun	1	0.4459	–28	0.2848	–24	0.2911
cus_sav_s_hun	4	0.2486	–28	0.2943	–24	0.3048
cus_finsit_s_hun		>0.2000	–23	0.3139	–23	0.3338
con_emp_s	0	0.3015	0	0.3590	–20	0.2594
ret_stock_s		>0.2000	0	–0.1743	–18	–0.3051
con_aob_s	2	0.3674	2	0.4249	–16	0.3727
cus_finsit2_s_hun	–10	0.2983	–5	0.2467	–10	0.2771

Note. See Appendix for the explanation of the abbreviations. In the case of missing values, the cross-correlation does not reach 0.2 at any lead/lag, and it is not possible to define a peak of the lead time.

2.3. Benchmark model

Since this study aims at creating a composite leading indicator, only the variables having leading properties were kept. After determining the lead time of the remaining time series, the next step was to regress them on the reference series. Each variable was set to precede the coincident index (i.e. the dependent variable of the equation) exactly by its peak of cross-correlation. Necessarily, the variables that proved to be insignificant were omitted from the model. The estimator of the variance-covariance matrix of *Newey–West* [1987] was calculated to obtain significance levels that are robust to autocorrelation and heteroskedasticity. The final model is introduced by Table 3.

Although the method proposed by *Stock–Watson* [1989], *Nyman* [2010] and *Rácz* [2012] and applied by *Balatoni* [2014] for the construction of composite leading indicators is a popular "solution", it was found that the principal component analysis and the dynamic factor models do not perform better in signalling the turning points and forecasting the path of the coincident index than an OLS[8] regression in the case of the Hungarian economy. Proponents of the former technique argue that besides losing degrees of freedom, multicollinearity may result in loss of efficiency due to

[8] OLS: ordinary least squares.

the several, possibly weakly correlated regressors. However, after careful examination of VIF[9], it was concluded that multicollinearity of the benchmark model is not a serious problem.

Table 3

Benchmark regression model

Dependent variable	dlog(*CI*)
Constant	**0.0053**
	3.3823
dlog(*con_bpnh_h*(–28))	**0.0371**
	1.8785
dlog(*con_nord_h_tc*(–27))	**0.0362**
	3.1851
dlog(*ind_ord_sh_ex*(–28))	**0.0968**
	6.8738
cus_majorp_diff_ger(–26)	**0.0002**
	2.7517
cus_majorp_diff_hun(–23)	**0.0002**
	4.3173
cus_pricet_diff_ger(–27)	**–0.00004**
	–1.5728

R-squared value	0.764212	Mean of dependent variable	0.001636
Adjusted *R*-squared value	0.752251	Standard deviation of dependent variable	0.005519
Standard error of regression	0.002747	Akaike info criterion	–8.903212
Sum of squared residuals	0.001042	Schwarz criterion	–8.739726
Log likelihood	657.9344	Hannan-Quinn criterion	–8.836784
F-statistic	63.89581	Durbin-Watson statistic	0.247348
Prob(*F*-statistic)	0.000000	Wald *F*-statistic	57.8065
Prob(Wald *F*-statistic)	0.000000		

Note. CI stands for coincident index. See Appendix for the explanation of other abbreviations. Sample period: January 2000–July 2014; method: ordinary least squares, Newey–West estimation of the variance-covariance matrix of the coefficients. Estimated parameters are in bold; *t*-statistics are in italics. Lead times are in parenthesis.

[9] VIF: variance inflation factor.

As Table 3 shows, hard and soft data in the model are balanced in such a way that three of them were used from both types. There are two variables capturing the construction sector, while only one the industrial production. The remaining variables are survey data both from Hungary and from Germany.

To investigate the parameters' robustness, we used recursive estimation of our model. Each time, the sample period started in January 2000, while its end shifted by one month from estimation to estimation. This method shows the evolution of each coefficients' (beta) value and the month when it became significantly different from zero. In our case it was May 2008; no significant change in the model parameters could be detected afterwards. The only exception was the difference between the expected and present price trends (*cus_pricet_diff_ger*(–27)) that became insignificant again for a short period of time (from September 2010 to July 2011).

In sum, the set of leading variables, the lead time and the model parameters are robust enough to use them for further analysis.

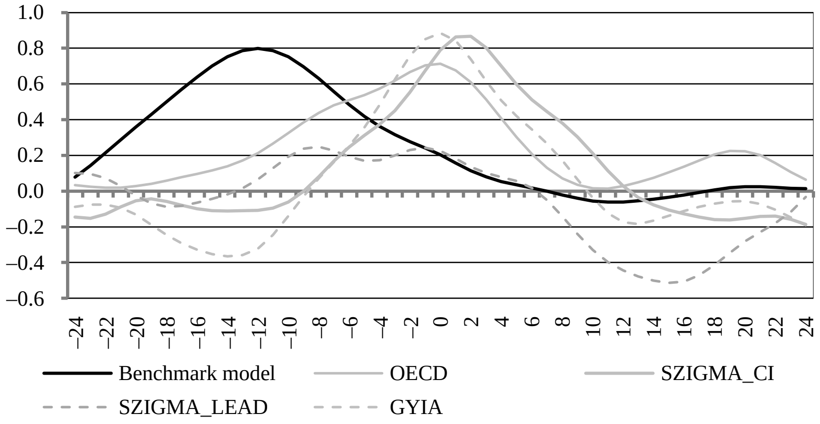
2.4. In-sample forecast performance of the benchmark model and other leading indicators

In this subsection, our benchmark model is compared with several other indices that capture economic momentum. Since it is only an in-sample forecast test, the performance of the benchmark model is compared with only that of indices with changing backcasts (ECOSTAT's GYIA, OECD leading indicator, SZIGMA CI[10] and SZIGMA LEAD[11]). These indices can be also interpreted as an in-sample fit of the respective model to the reference time series.

First, cross-correlation analysis and turning point detection tests are carried out at a monthly frequency. Data for our benchmark model are available from January 2002, thus, this is the maximum time span to be used. The OECD leading indicator is available for the same period as the SZIGMA indicators. GYIA is accessible from January 2006. Figure 2 shows that cross-correlation at zero lead or lag is the highest in the case of GYIA and SZIGMA CI. Therefore, these can be considered as the best coincident indices. However, if the lead time is increased (see left-hand side on the horizontal axis), the cross-correlation coefficient of all leading indices "rapidly fades away". On the contrary, LeadING HUBE's correlation increases significantly and reaches the peak at the 12-month lead time. Hereby, our target to construct an index giving information about the future state of the business economy is achieved.

[10] It summarises the current state of the economy in a single figure.
[11] It provides an overview of the prospective economic growth in nine months (three quarters).

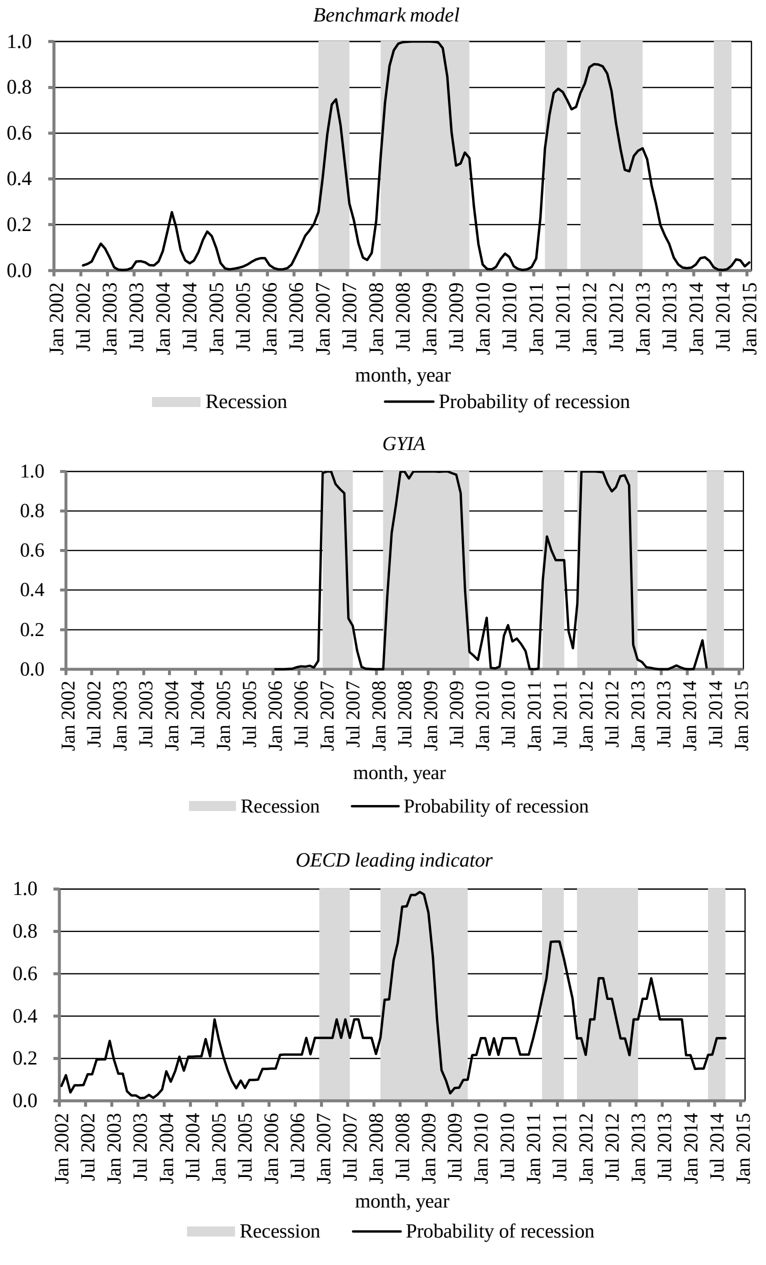
Figure 2. Cross-correlation between various leading indices and our benchmark model
(monthly percentage changes)

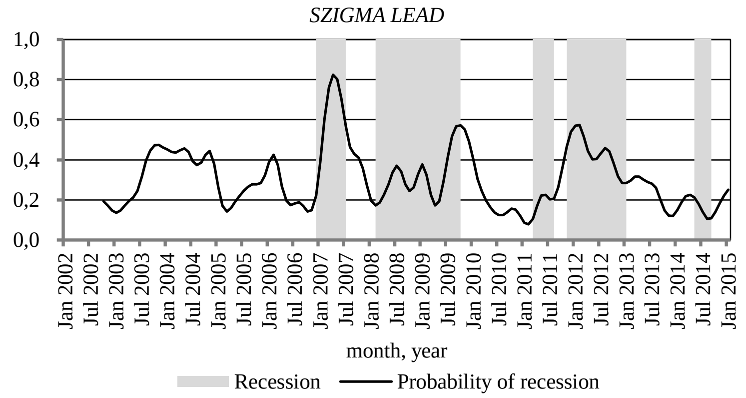


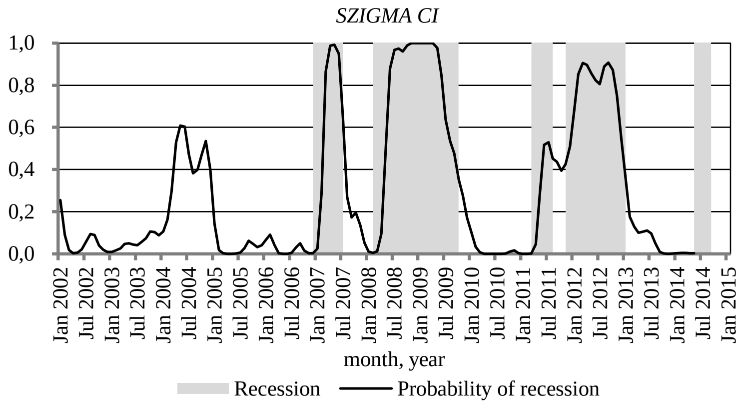
Note. The cross-correlation represents the correlation of the coincident index at time *t* and the other leading variable at time *t* + *n*, where *n* stands for the number of months by which the time series is shifted.
Source: Bloomberg, Századvég and OECD data as well as own calculation.

To demonstrate the performance of LeadING HUBE in turning-point detection, an artificial binary (dummy) variable is created that takes the value of 0 if the economy is expanding and 1 if the economy is in recession, according to the coincident index. (Recession is defined here as three consecutive months of decreasing output.) Then a binary outcome model is estimated in which the explanatory variable is our benchmark model with 12 leading months. Since the other indices would correlate poorly with the coincident index with the same lead time, they are included in the regression with no lead time or (in the case of SZIGMA LEAD) with nine-month lead (because the cross-correlation coefficient reaches its maximum nine months earlier than the actual value of the coincident index). The results are shown by Figure 3.

Figure 3. Probability of recession estimated by the benchmark model, GYIA, OECD leading indicator, SZIGMA LEAD and SZIGMA CI







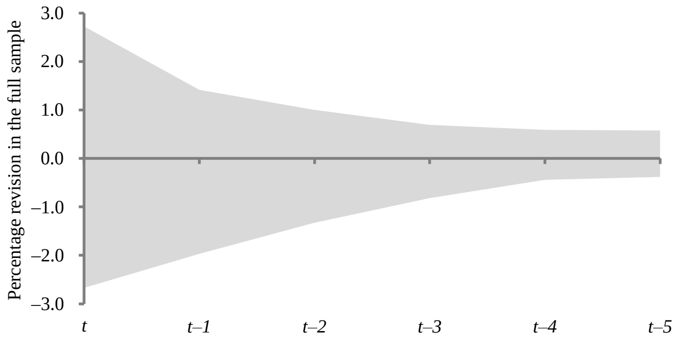
Our benchmark model has outperformed the OECD leading indicator and SZIGMA LEAD, while its performance almost reached the results of the coincident indices (GYIA and SZIGMA CI) that do not have lead time and thus, do not provide additional information about the future state of the business economy.

2.5. Calculation of LeadING HUBE

Our benchmark model was a good in-sample leading variable, but the lack of need for revision is also an important feature when the robustness of an indicator is assessed. As it was revealed in subsection 2.2., our set of leading variables as well as their lead time were "more or less" stable. By means of recursive parameter estimation, it was also presented ,that the regression parameters did not change significantly after 2008, so these elements of our model can be considered as a stable structure. However, we still have to solve the so-called end-point biasedness of the Henderson filter.

To account for the end-point uncertainty of the smoothed time series as a consequence of using this filter (for more details see *Proietti–Luati* [2008]), for each time period, the last four calculated data points of every time series were omitted from the further work (and hence from the calculation of the index). Despite the fact that this "deletion" makes four-month "foresight" or lead time prior to the reference date lost, the stability and reliability of the index improves significantly. Nevertheless, LeadING HUBE still has eight-month lead time, which is a great advantage compared with other leading indices. Figure 4 confirms our decision to omit the last four observations owing to the problem of end-point biasedness. At the end of the sample, the revision can reach even 2.5% (both negative and positive percentage deviation from the underlying trend), but the further (in months) the observations from the endpoint of the sample, the smaller the revision is. Therefore, the revision entailing four-month "deletion" is considered acceptable.

Figure 4. Revision of the coincident index at different distances (in months) from the endpoint



To calculate the final LeadING HUBE, the Henderson filter was used to smooth out both the explanatory variables and the coincident index. Then the last 4 months of the sample were split and a twelve-month forecast for the coincident index was implemented with the benchmark model. (See Table 2.) Next, in each sample period, the forecasted growth figures were linked in a chain fashion (just like in *Kertész–Kucsera–Szentmihályi*'s study [2015]). This chain-linked index is actually the LeadING HUBE, which means, it did not need revision. The parameters of the model became "stable" in 2008, so the index could be calculated from the second half of that year.

Since the final LeadING HUBE is available only for a short period, we cannot test properly its out-of-sample forecast performace with the usual tools (cross-correlation and turning point detection). However, it is still interesting to check at least graphically the comovement of LeadING HUBE and the coincident index in the last few years. Figures 6 and 7 illustrate that their correlation is significant at 4-5 months of lead. LeadING HUBE captures the underlying momentum of the economic growth because unlike the coincindence figures (that had large swings in their monthly changes between 2010 and 2012 and showed a peak in the beginning of 2015), it is not characterized by high frequency volatility.

Figure 5. Percentage changes of LeadING HUBE, August 2008–August 2015

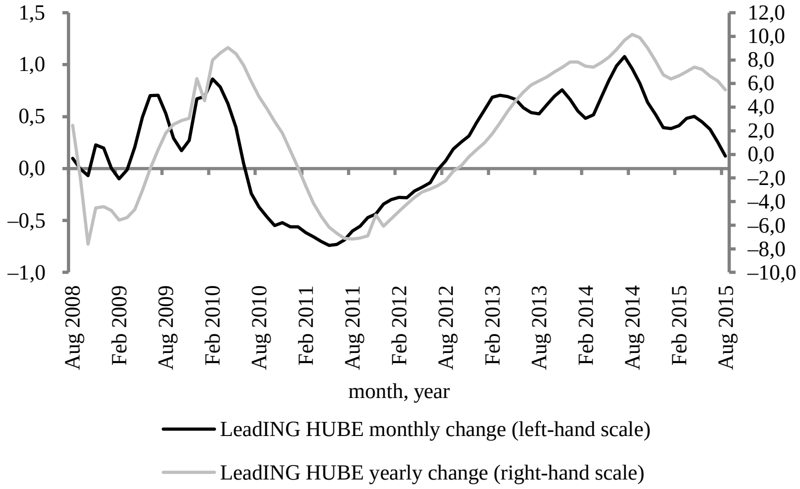
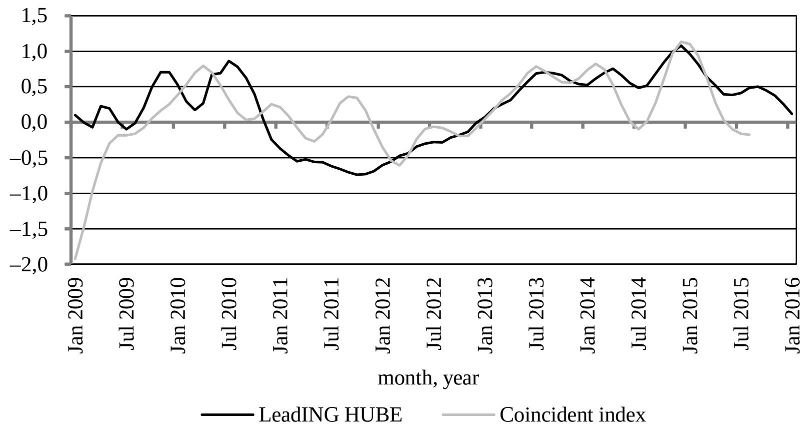
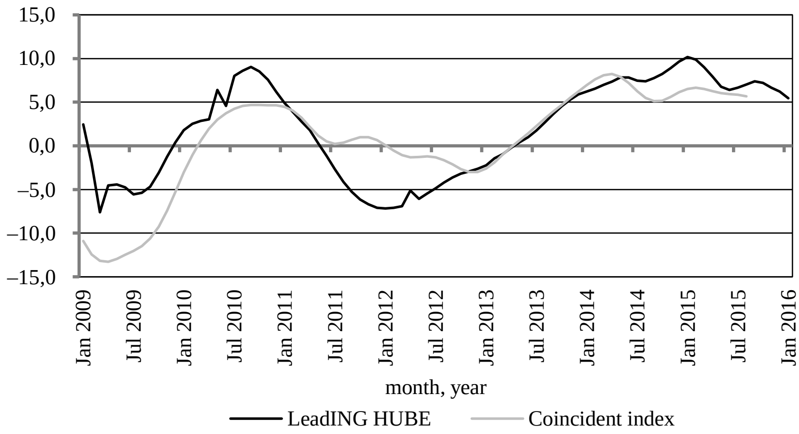


Figure 6. Comovement of LeadING HUBE and the coincident index, January 2009–January 2016
(monthly percentage change)



Note. LeadING HUBE has been delayed by 5 months.

Figure 7. Comovement of LeadING HUBE and the coincident index, January 2009–January 2016
(annual percentage change)



Note. LeadING HUBE has been delayed by 5 months.

In sum, LeadING HUBE performed well in out-of-sample forecast for the last few years, and represented sufficiently (without any revision) the underlying momentum of the Hungarian economic activity. Therefore, by publishing it monthly, we would provide valuable information for decision makers, traders and the public.

3. Summary

In this study, a new leading indicator for the Hungarian business economy was introduced. First, the general methods for the construction of composite leading indicators were described, and then the creation of LeadING HUBE was presented. The main purpose of this new composite leading indicator is to predict the probable path of the private sector performance with significant lead and certainty. In the last part of the study, LeadING HUBE was compared with several other indicators developed for the Hungarian economy, and it was demonstrated that it outperformed them with respect to reliability and lead time. We hope that LeadING HUBE can be a useful tool for both analysts and economic decision makers.

Appendix

Potential leading variables

Variable	Source	Unit	Denoted by
Volume of industrial export order book level divided by the volume of industrial production	HCSO	2010 = 100	*ind_ord_sh_ex*
Issued non-residential building permits	HCSO	m^2	*con_bpnh_h*
Volume of industrial order book level	HCSO	2010 = 100	*ind_ord_h*
Household survey: difference between the expected and present price trends – Germany	Eurostat	balance	*cus_pricet_diff_ger*
Volume of new orders in construction	HCSO	2010 = 100	*con_nord_h*
Household survey: difference between the expected and present major purchases – Germany	Eurostat	balance	*cus_majorp_diff_ger*
Household survey: difference between the expected and present major purchases – Hungary	Eurostat	balance	*cus_majorp_diff_hun*
Household survey: savings – Germany	Eurostat	balance	*cus_sav_s_ger*
Household survey: savings in the next 12 months – Germany	Eurostat	balance	*cus_save_s_ger*
Household survey: price trends – Germany	Eurostat	balance	*cus_pt_s_ger*
Stock of orders in construction	HCSO	2010 = 100	*con_ord_h*
Household survey: price trends – Germany	Eurostat	balance	*cus_pt_s_hun*
Household survey: price trends expectation – Hungary	Eurostat	balance	*cus_pte_s_hun*
Household survey: major purchases at present – Hungary	Eurostat	balance	*cus_mp_s_hun*
Household survey: savings in the next 12 months – Hungary	Eurostat	balance	*cus_save_s_hun*
Household survey: expected financial situation – Hungary	Eurostat	balance	*cus_finsite_s_hun*
Household survey: general economic outlook – Hungary	Eurostat	balance	*cus_genee_s_hun*
Household survey: major purchases in the next 12 months – Hungary	Eurostat	balance	*cus_mpe_s_hun*
Household survey: general economic situation – Hungary	Eurostat	balance	*cus_gene_s_hun*
Household survey: savings – Hungary	Eurostat	balance	*cus_sav_s_hun*
Household survey: financial situation – Hungary	Eurostat	balance	*cus_finsit_s_hun*
Construction survey: employment expectations	Eurostat	balance	*con_emp_s*
Retail survey: stock levels	Eurostat	balance	*ret_stock_s*
Construction survey: order book levels	Eurostat	balance	*con_aob_s*
Household survey: statement on the financial situation of households	Eurostat	balance	*cus_finsit2_s_hun*

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