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LABOUR COSTS IN THE AEROSPACE INDUSTRY: LMDI DECOMPOSITION OF AEROSPACE MANUFACTURING PAYROLLS

KOSZTY PRACY W PRZEMYŚLE LOTNICZYM: LMDI, ROZKŁAD PŁAC ZA PRODUKCJĘ LOTNICZĄ

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Abstract: A novel approach to aggregated payroll data analysis using the logarithmic mean Divisia index decomposition is applied to the US Aerospace manufacturing industry during the period of 1998 to 2012, both in nominal and real terms. The period covered improves the understanding of how the aerospace manufacturing industry deals with severe economic blows in the area of the most important factor of production, namely labour. The decomposition was based on three factors: the wage effect, the size and the number effect. The results show that the wages are less influential than the restructuring processes when considering the aggregated payroll. Unlike what simple wage indices suggest, the wage effect in real terms contributed only to a moderate increase in payrolls by a factor of 1.15, which is about the same contribution resulting from the increasing number of firms in the industry. The cumulative size effect in the investigated period was about 0.647. The results show that the relatively stable real labour costs of the US aerospace industry were a consequence of the shrinking size of firms which compensated the growth of average wages.

Keywords: LMDI, aerospace, payroll, wages.

Streszczenie: Nowatorskie podejście do zagregowanej analizy danych płacowych z wykorzystaniem średniej logarytmicznej rozkładu indeksu Divisia zostało zastosowane w przemyśle wytwórczym US Aerospace w latach 1998-2012, w ujęciu zarówno nominalnym, jak i realnym. Omawiany okres pozwala lepiej zrozumieć, jak przemysł lotniczy i kosmiczny radzi sobie z poważnymi ciosami gospodarczymi w obszarze najważniejszego czynnika produkcji, jakim jest praca. Dekompozycja opierała się na trzech czynnikach: efekcie płacowym, wielkości i efekcie liczbowym. Wyniki pokazują, że płace mają mniejszy wpływ niż procesy restrukturyzacyjne, jeśli wziąć pod uwagę zagregowane listy płac. W przeciwieństwie do tego, co sugerują proste indeksy płac, efekt płacowy w ujęciu realnym przyczynił się jedynie do umiarkowanego wzrostu wynagrodzeń o współczynnik 1,15, czyli mniej więcej o tyle samo, ile wynika z rosnącej liczby firm w branży. Łączny efekt wielkości w badanym okresie wyniósł około 0,647. Wyniki pokazują, że relatywnie stabilne realne koszty pracy w amerykańskim przemyśle lotniczym były konsekwencją zmniejszania się wielkości firm, co rekompensowało wzrost średnich płac.

Słowa kluczowe: lotnictwo, płace, wynagrodzenie.

1. Introduction

The airline industry underwent severe shocks even before the current epidemic (see e.g. Chin, Hooper, and Oum, 1999; Morrell, 2011; Franke and John, 2011; Pearce, 2012) and also transformations such as low-cost airlines. The crisis affected not only the airlines themselves but also the hubs (see e.g. Barros, 2004 and Coto-Millan et al., 2014). Although the literature is quite extensive and the crisis manifesting itself in the form of a reduced demand seemed to be over (Pearce, 2012), one aspect was missing. The industry is heavily capital-intensive (Bjelicic, 2012) and scant attention is paid by airline companies to the changes in the aerospace industry. The air transport industry is already a high-risk business that can destroy the expectations and businesses quickly as the current situation shows. The interconnections are tight and volatile (Bjelicic, 2012).

While considered as one of technological backbones of the US manufacturing base (Platzer, 2009), the airline manufacturing is also very sensitive to both air transport demand[1] and international markets (see e.g. Platzer, 2009, who reported an annual figure of about 95 billion USD in vehicle export sales and 37 billion USD in aerospace product imports), very flexible with utilization of capital (airplanes to be more specific) (Chin, Hooper, and Oum, 1999) and it is also over-invested.[2] This makes the industry very unstable and causes expectations to be rarely met. Obviously, this situation must be taken into account by the aircraft manufacturers,

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[1] Which in itself can be very sensitive to various factors, both economic and non-economic (such as political or regional conflicts, natural phenomena, disease outbreaks, terrorist attacks etc.).

[2] The returns to capital are below expectations, which is a sign to withdraw the capital invested into the industry. An interesting discussion on this subject was offered by Pearce (2012). These problems are, however, not limited only to the airlines as examined by Ramey and Shapiro (2001).

and it makes their long-run planning very difficult. This further increases the risks that should be taken into consideration while estimating and preparing their price policies, in turn influencing the airlines. This dubious circle between the airlines and aircraft manufactures opens up the space for making wrong decisions at a bad time.

Nevertheless, the aerospace industry is volatile and requires highly skilled workers who are difficult to find (cf. Butler, 1967; Butler, Podrasky, and Allen, 1977; Goldstein, 2002; Cutcher-Gershenfeld, 2004; Rossetti and Choi, 2005; Sleigh, Calhoun, and Cutcher-Gershenfeld, 2006) and it has been transforming and consolidating, too (Anderson, 1995; Dussauge and Garrette, 1995), it was also partly affected by Obama's reform of space transportation systems (Delgado, 2011; Chapman, 2015). The airlines should also consider the transformation of the aerospace industry in their strategies.

The aim of this paper was to decompose the development of the annual payroll in the American aerospace industry in order to evaluate the effects of structural changes within the industry up to the end of the last business cycle.

This analysis can be viewed as labour cost analysis, in terms of a more complex look at the industry's payrolls at the critical time of the last already finished business cycle. Such analysis might be useful in airline strategic planning, collective bargaining or for prospective investors. A conventional analysis would likely put forward a production function with the primary focus on the resource transformation and elasticity (in the context of labour unions and industry analysis, see e.g. Hirsch, 2004). The authors focused instead on the labour situation, wages and payrolls – highly relevant in collective bargaining. To do this, they employed the payroll decomposition approach. The decomposition methods have found a significant range of application in the energy and environmental economics, but to the best of the authors' knowledge, they have not been applied regarding payrolls and wages.

A better understanding of the topic at hand can be of help to all interested parties in their current complex decision-making processes induced by the epidemic. The epidemic, as well as the continuation of outsourcing and/or privatization of US space activities which are closely linked, will undoubtedly have drastic consequences for the industry and especially its labour force.

2. US aerospace manufacturing industry payrolls

This section provides a brief background analysis of the US aerospace industry. The annual payroll figures represent a significant portion of manufacturers' costs. Furthermore, the aerospace manufacturing workforce earns on average even 50% more than the aggregate manufacturing workforce, and the aerospace manufacturing workforce is also more highly unionized (a detailed overview of the US aerospace manufacturing industry, including the historical overview of structural changes, can be found in Chapter 9, in Kaps, Hamilton, and Bliss, 2012). However aerospace manufacturing usually also requires much higher quality levels of human capital (often minimum of a Bachelor's degree in the respective specialized technical field), which may prove to be a pressing concern, as there are apparent difficulties with finding such workers (Platzer, 2009; Kaps et al., 2012), even more pronounced in aerospace manufacturing than in the other manufacturing sectors (see Woods, 2009). This is, however, only a partial explanation as to why a large part of their current revenues is still paid to labour in such a capital-intensive industry. Unsurprisingly, there has been a longer and deeper research interest in labour (rather than in the capital aspect) of the aerospace and/or airline industry (cf. Peoples, 1990; Erickson, 1992; Alamdari and Morrell, 1997; Hirsch and Macpherson, 2000 and Melo Filho, Salgado, and Sato, 2014). Nevertheless, the payrolls (as an aggregate variable) hardly draw similar attention as wages and productivity do – even though they can provide a deeper insight into the structural changes in the industry.

Mostly the research interest in payrolls is caused by the taxes-payrolls relationship (see e.g. Mitrusi and Poterba, 2001; Kugler and Kugler, 2009). Typically, the payrolls are not analysed as an aggregated variable. There are exceptions: Huntsinger et al. (2012) studied the relation between merit pay and payroll development, while Hundley (1993) used the payroll as a tool in his analysis of public/private relative wages. Otherwise, payrolls are used as an intermediary in the research (cf. Shearer, 1996; Ferrall and Shearer, 1999; Paarsch and Shearer, 2000). The research potential of payroll data, and in particular aggregated payroll data, has not been yet sufficiently exploited despite the substantial research regarding labour's share of revenue (cf. discussion in Fichtenbaum, 2011).

In recent years an interesting disproportion was also indicated in the real data of US aerospace manufacturing. The real total payrolls did not change significantly, while the employment dropped and the real wage grew. Arguably, the industry has recently undergone a dramatic development. This restructuring process raises a question of whether the drop in employment was proportional to the rise of real average wages while the real total payrolls did not significantly change, or whether there were other factors influencing the real total payrolls. These reasons led to the research question: was the almost unchanged real total payroll the result of the aerospace industry's restructuring rather than the combination of rising real wages and falling employment?

In order to decompose the development of annual payroll in the American aerospace industry to evaluate the effects of structural changes within[3] the industry the authors applied the logarithmic mean Divisia I index method (LMDI) proposed by Ang and Liu (2001). This allowed to attribute the changes to three separate factors – the wage effect, the average firm size effect (the size effect in short) and the number of firms effect (the number effect in short).

[3] It is also possible to apply the decomposition in spatial fashion, though it is done relatively scarcely – examples include Ang and Zhang (1999), de Nooij et al. (2003), Alcántara and Duarte (2004), Hasegawa (2006), Hajko (2012), and Xu and Ang (2014).

The remainder of the paper consists of two major sections. Firstly, the approach to the analysis and the methodology with data were presented. Secondly, the authors briefly discussed the results and highlight the consequences for the airline industry.

3. Methodology and data

3.1. Index decomposition methods

Users of any economic index (most often price or quantity indices) often want to know how much each item included in the overall figure contributes to a change in the index. The index decomposition methods provide exactly this kind of explanation.

The change in an aggregate, denoted by e.g. V, can be expressed either as $D = \frac{V^T}{V^0}$ in multiplicative form or $\Delta V = V^T - V^0$ in additive form. The decomposition means the total change is attributed to several factors, so that $D = \frac{V^T}{V^0} \cong \prod_{k=1}^{n} D_k$ or $\Delta V = V^T - V^0 \cong \sum_{k=1}^{n} \Delta V_k$.

Their use naturally gained large prominence in statistical offices. The traditionally applied methods based on the Laspeyres or Paasche index formulas allow for the straightforward calculation of the contributions of individual factors. Nevertheless, with more complex methods such as the geometric mean index, the Tornqvist index and the Fisher index, the quantification of the contribution of individual factors is not as straightforward and requires consideration of the index number properties. See Reinsdorf et al. (2002) for a more detailed discussion.

Furthermore, since approximately the 1970s, the index decomposition methods have been gaining strong ground in the research dealing with energy and environmental issues, and serve as an analytical tool for policy-making (Ang, 2004), employed by renowned international bodies such as the International Energy Agency (IEA, 2011) (though the authors are not aware of any research applying any form of index decomposition analysis to wages or payrolls). In particular, Ang and Zhang (1999) provided a review of the historical applications of index decomposition analysis.

There is a large variety of methods, but some can be viewed as better than others. Fisher (1967) proposed a series of tests (or properties) that the decomposition method should fulfill, among which the literature identifies as the most important: the factor--reversal test, the time-reversal test and the zero-value robustness (Ang and Zhang, 1999).

Probably the most important among these is the factor reversal test. This test requires that the product (for the multiplicative form) or the sum (for the additive form) of the individual factor contributions must equal the observed change in the aggregate – hence the decomposition must be perfect, leaving no unexplained residual. The test can be expressed as $D^{0T} = \frac{E^T}{E^0} = \prod_{k=1}^{n} D_k$ for the multiplicative form or $V^T - V^0 = \sum_{k=1}^{n} \Delta V_k$ for the additive form.

The time reversal test, as the name suggests, requires that the index number for a change from period $t = 0$ to $t = T$ must be a reciprocal value (for the multiplicative form) or the negative (for the additive form) of the calculated index number for the change from period $t = T$ to period $t = 0$. This can be expressed as $D^{0T} = \frac{1}{D^{T0}}$ or $\Delta V^{0T} = -\Delta V^{0T}$.

Zero-value robustness simply means the method has to be able to deal with the presence of zero values in the dataset.

The LMDI method applied in this article passes Fisher's test (with the exception of the circular test[4]). LMDI is also zero-value robust with a very simple modification of the dataset, namely replacing the zero values by very small number ($\delta = 10^{-20}$), as described in Ang and Choi (1997). Further methodological discussion of zero-value robustness can be found in Ang and Liu (2007).

It should be noted that some refined additive Laspeyer's index decomposition methods, for example Sun (1998), Diezenbacher and Los (1998), Albrecht, François, and Schoors (2002), also fulfill Fisher's factor-reversal and time-reversal tests, but the complexity of the interaction terms in these methods grows very quickly and they also do not offer transformation to a multiplicative form. One can find an extensive comparison of the properties of the various decomposition methods in Ang and Zhang (1999). A detailed overview and evaluation of the suitability of the index decomposition methods can also be found in Ang (2004), who argued that the LMDI is the most suitable method for both additive and multiplicative variants linked to the Divisia index, Fisher's ideal index method is the most suitable for the multiplicative method linked to the Laspeyres index, and that the Shapley/Sun or Marshall-Edgeworth method should be used for the additive decomposition linked to the Laspeyres index.

3.2. Methodology

The authors calculated the changes in the overall payrolls in the NAICS 3364 industry. The basic relationship for decomposition is:

$$P = \sum_i P_i = \sum_i \frac{P_i}{L_i} \frac{L_i}{N_i} N_i = \sum_i W_i S_i N_i, \qquad (1)$$

where P_i represents payroll in sub-sector i, L_i represents the number of people employed in sub-sector i and N_i represents the number of establishments in sub--sector i, $\frac{P_i}{L_i} = W_i$ represents average wage and $\frac{L_i}{N_i} = S_i$ represents average size of the firm.

4 The circular test has the form $1 = D^{0S} + D^{ST} + D^{T0}$ where S is a point between time $t = 0$ and $t = T$. As was shown by Fisher (1967), the circular test is not passed by *any* weighted aggregative with changing weights.

After differentiating and some manipulation, one obtains:

$$P^T - P^0 = \int_0^T \left(\sum_i a_i(t) \frac{\partial}{\partial t} ln\left(W_i(t)\right) + \sum_i a_i(t) \frac{\partial}{\partial t} ln\left(S_i(t)\right) + \sum_i a_i(t) \frac{\partial}{\partial t} ln\left(N_i(t)\right) \right) dt, \quad (2)$$

where $a_i = W_i(t)S_i(t)N_i(t)$. Since one only observes discrete data, discretization of the equation (2) results in:

$$P^T - P^0 \cong \sum_i a_i\left(t^*\right) ln\left(\frac{W_i^T}{W_i^0}\right) + \sum_i a_i\left(t^*\right) ln\left(\frac{S_i^T}{S_i^0}\right) + \sum_i a_i\left(t^*\right) ln\left(\frac{N_i^T}{N_i^0}\right). \quad (3)$$

There are several options for $t^* \in \left(0,T\right)$ in Equation (3). Since some weighting schemes exhibit a desirable behaviour, namely passing the factor reversal test (in other words, perfect decomposition without any residual), the study applied the LMDI weighting scheme given as logarithmic mean of payrolls in time $t = T$ $t = T$ and time $t = 0$, i.e. $\tilde{a}_l = L\left(P_i^T, P_i^0\right)$. Thus the perfect decomposition is:

$$P^T - P^0 = \underbrace{\sum_i \tilde{a}_i ln\left(\frac{W_i^T}{W_i^0}\right)}_{\text{Wage effect}} + \underbrace{\sum_i \tilde{a}_i ln\left(\frac{S_i^T}{S_i^0}\right)}_{\text{Size effect}} + \underbrace{\sum_i \tilde{a}_i ln\left(\frac{N_i^T}{N_i^0}\right)}_{\text{No. of firms effect}}. \quad (4)$$

These effects describe how industry payroll would alter due to the change in one of the pre-defined factors, if the other factors remained the same.

The wage effect describes the impact of average wage increase (or decrease) in the given sub-sector, the size effect describes the impact on payrolls resulting from the increasing (or decreasing) size of the average firm, and number of firms effect indicates the impact of an additional firm in the sub-sector (or a firm leaving the sub-sector).

Note that the multiplicative decomposition can be derived in a similar fashion. Since with LMDI it holds that $\frac{\Delta V_{total}}{\ln\left(D_{total}\right)} = \frac{\Delta V_{effect_1}}{\ln\left(D_{effect_1}\right)} = \frac{\Delta V_{effect_2}}{\ln\left(D_{effect_2}\right)} = \ldots = \frac{\Delta V_{effect_k}}{\ln\left(D_{effect_k}\right)}$, one can easily compute the results for the multiplicative decomposition from the results of the additive decomposition and vice versa.

3.3. Data

The data for the analysis were collected from the US Census Bureau County Business Patterns database for all the sub-sectors of the NAICS 3364 industry[5]. Annual payrolls are measured in 1000 USD. Employment and number of establishments are measured in cardinal values. In order to calculate real payroll, the study used

[5] There are 6 sub-sectors; 336411, 336412 and 336413 are aircraft; aircraft engine and engine parts; and other aircraft parts and auxiliary equipment manufacturing sectors. The sectors 336414, 336415 and 336419 are separated accordingly for the guided missile and spacecraft manufacturing.

Consumer Price Index (World Bank indicator FP.CPI.TOTL, with base year 2010=100).

Even though the nominal payroll in the aerospace industry increased from 26.9 billion USD in 1998 to 32.3 billion USD in 2012, Figure 1 shows that in real terms it is only about 85% of what it was in 1998. One can see the aerospace industry and its payroll have never recovered from the slump continuing up to 2003 (with the lowest point of 74% of the payroll in 1998). The only sub-sector with an increased payroll is 336419 (i.e. Other guided missile and space vehicle parts and auxiliary equipment manufacturing) that managed about a 2.7% increase (in 15 years).

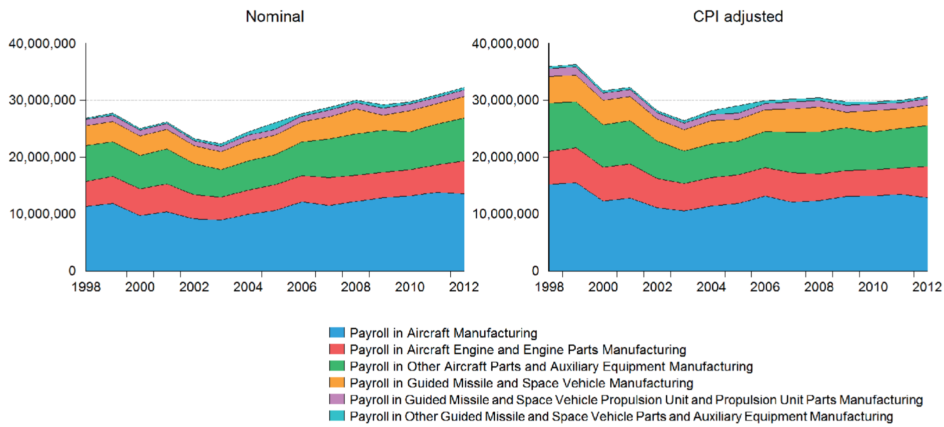

Fig. 1. Payrolls in the aerospace industry

Source: own work.

The study's main interest lies in the structural changes in the aerospace industry. To approximate the structural changes the authors used the average nominal and real wage in the given sub-sector which reflects the unit labour costs (wage effect); the size of the firm which reflects the health or stability of the given sub-group – the larger the firms, the more stable the market environment – however also less competitive[6] (size effect); and the number of firms in the given sub-industry which reflects the dynamics of the industry – newly established or divided firms or firms that left the market (firms effect). The descriptive statistics of variables is presented in Table 1.

[6] Larger firms also tend to pay higher wages (see e.g. Dunn, 1986; Morissette, 1993; Fafchamps and Soderbom, 2006; Ferrer and Lluis, 2008). The transformation of the industry is supposed to affect the size of the average firm as the critical market environment makes the firms become more efficient. This in turn affects the payrolls.

Table 1. Means of variables (std. dev. in parentheses), by sub-sectors

	Avg. wage	Avg. wage – CPI adjusted	No. of firms	Firm size	Employment share
336411	69.45 (12.5)	76.79 (5.66)	274.5 (27.87)	618.0 (148.33)	0.40 (0.01)
336412	62.56 (7.25)	69.66 (2.68)	419.1 (29.95)	179.8 (28.4)	0.18 (0.01)
336413	58.66 (8.1)	65.13 (2.23)	913.9 (124)	118.1 (7.11)	0.26 (0.01)
336414	80.91 (11.14)	89.96 (5.44)	25.9 (7.16)	1869.6 (666.14)	0.11 (0.01)
336415	73.43 (10.43)	81.56 (4.23)	27.5 (2.77)	544.2 (89.05)	0.04 (0)
336419	64.64 (12.37)	71.53 (8.17)	52.9 (5.38)	131.9 (35.47)	0.02 (0.01)

Source: own work.

Nominal average wages rose significantly over all the time period (as shown in standard deviations). It is no surprise that spacecraft manufacturing industry wages are higher than in the aircraft manufacturing, partly due to the greater human capital accumulated within the sector for the use in microgravity engineering. It is also a consequence of the smaller size of this sub-industry (approximately six times smaller) and hence the less intensive competition between employees.

Aircraft manufacturing is served by more firms which are on average smaller than those operating in spacecraft manufacturing. The number of firms and their size fluctuated significantly too. This is a sign of the changes and structural adjustments in the given time period.

Nominal wages were rising significantly in all the sub-groups as well as the nominal total payroll. The growth of real wages was less significant and there were some decreases in real wages. The consolidation hit the aerospace industry very hard. Total employment dropped from around 518 thousand employees in 1998 to approximately 387 thousand in 2012. This decrease could be attributed mostly to aircraft manufacturing. The average size of the companies also sharply decreased. The reason for this drop is not only attributed to the fall in employment but also to the growth of the number of firms. With one exception – the number of firms was reduced by around 250 companies in the aircraft parts and equipment manufacturing (336413). The next section presents the results of the analysis.

4. Results

Compared to 1998, the total nominal payroll has increased by 20%. This might seem like a substantial rise in the costs of the aircraft manufacturers (and hence motivating the rise in aircraft prices). The first look at the wage indices might lead to the usual suspect of increasing wages – wages rose nominally by 50% to 80% in all sub--sectors, and one can see a somewhat similar pattern in real wages as well, although on a substantially lower scale of about 10% to 20% over the examined period.

A CPI-adjusted number however reveals that the real total payrolls in the aerospace manufacturing were sharply decreasing from 1998 to 2002, and despite some return to growth since 2003, they still would need to rise by about 15% to even match the values in 1998. The decomposition can show what the major driving factors of this development were.

The results of the decomposition can be viewed from multiple angles (detailed year-by-year figures are provided in the Annex). In the analysis the authors focused on two facets: the individual effects compared across sub-sectors, and the aggregated effects for the whole aerospace manufacturing. Figure 2 presents the former, i.e. the cumulative individual effects on payrolls in each sub-industry. In most of the sub-industries the cumulative wage effect influenced the real total payrolls in a moderate positive way, leading to the growth of real total payrolls. One can clearly see that, in real terms, wages were not the dominant factor in the development, even if accounting for the influence of the clearly dominant 336411 sub-sector.

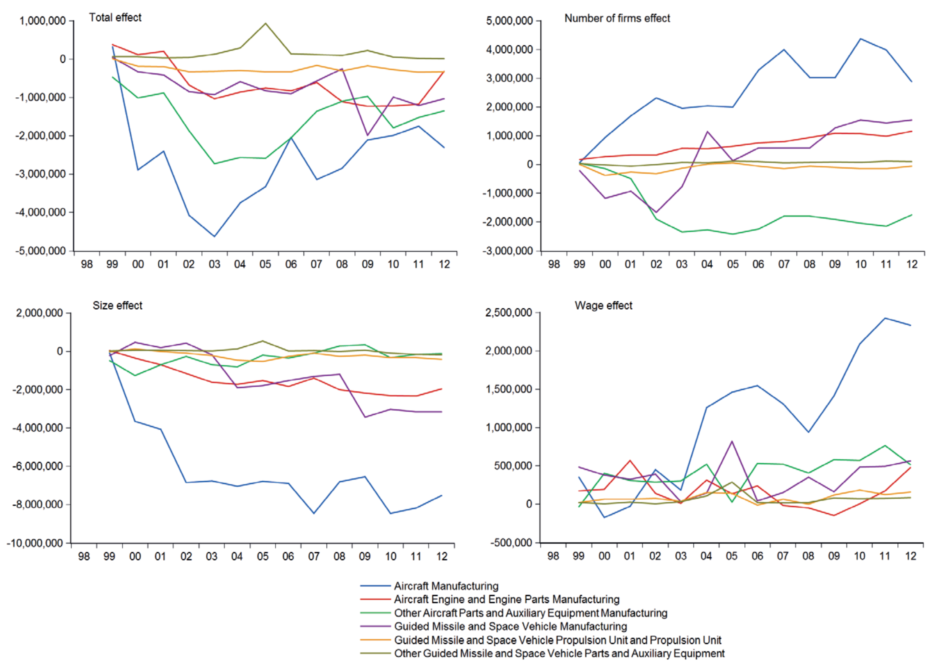

Fig. 2. Cumulative effects on CPI-adjusted payrolls

Source: own work.

Figure 3 shows the effects aggregated by the sub-sectors: here the wage effect was seemingly dominating the payroll growth for the whole aerospace manufacturing, increasing the total payrolls by a factor of 1.6. Nevertheless, if one considers the measurement in real terms, it can be clearly seen that this effect was much lower, only amounting to a moderate increase by a factor of 1.15 (note that this is the total cumulative increase for the whole period of 13 years)[7]. What is apparent from the figures is that, while the number of firms was rising, and hence increasing the pressure on the payroll figures, it was more than compensated by the decreasing size of the firms. The most significant drop can be attributed again to the largest sub--industry, aircraft manufacturing, followed by spacecraft manufacturing. The average firm size in these sub-sectors decreased from approximately 950 to 530, and from 2500 to 1000, respectively. This indicates a decline in the previous dominance of the aerospace manufacturing by Boeing and Lockheed-Martin. New and rather small firms have been entering the playing field, and this more competitive environment has, surprisingly, driven the (real) payroll figures down. These conclusions clearly do not follow the usual expectations that large, often dominant companies (in their respective markets) will exercise their market power towards the share of the labour's income (though the results in Fichtenbaum, 2011, might suggest this could also have been caused by declining unionization in these new firms).

The results suggest that managers of aerospace and also of airline industry should not overstress the economic impact of changes in the real wages of their employees, because in most of the sub-industries the rise of the real wage has not been the major factor influencing the total payrolls and hence the costs.

Another factor considered in this analysis was the number of firms. In this case the study observed two tendencies in the data. First, the number of firms reported by statistical data slightly rose during the analysed time period. Second, in airplane parts and equipment manufacturing, the number of firms dropped significantly from 1100 plus firms in 1998 to 881 in 2012. While in other sub-industries the competition was increasing as the market allowed for more firms to survive or to outsource some firm's activities to newly established firms, in the NAICS sector 336413 a quick and significant consolidation took place. Hence, the payrolls would ceteris paribus rise except in the case of the 336413 sub-industry.

After a discussion of the sub-industry payrolls development under the given effects, Figure 3 presents the cumulative multiplicative industry-wide effects. Based on the decomposition, the nominal industry-wide payroll rose mainly due to the fact that the nominal wages also rose, and that there were more firms operating in most of the sub-industries which outweighed the fall in the number of establishments in the 336413 sub-industry. Yet the size effect generated a tendency for the payroll to decrease.

Nevertheless, one should be more concerned with the real payroll than with the nominal payrolls. Wages are often an argument used in difficult times, but the decomposition shows that – considering only the contribution of the change in wages, with other things being unaffected – the real wage growth would result only

[7] This is arguably the main cause of relatively low attractivity of the field, leading to insufficient numbers of qualified workers to meet the needs of the industry demanding relatively high human capital levels.

in an approximate 10% rise of the industry-wide real payrolls during the whole time period. It is noteworthy that in real terms, the effect of the number of firms operating in the given sub-industry was in terms of magnitude very similar to the real wages effect.

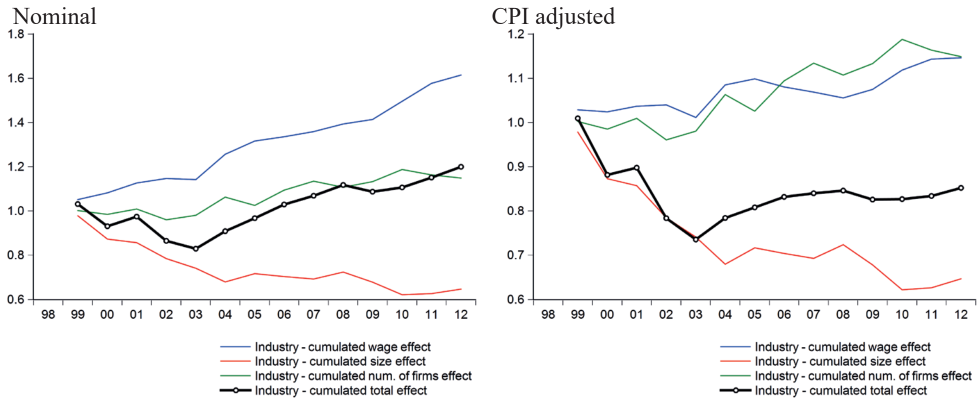

Fig. 3. Cumulative multiplicative effects for 3364 industry

Source: own work.

The major factor preventing the real payrolls from a rise was the size effect. Hence, the changes that were going on in the industry had a favourable cost impacts. The firms (and the whole aerospace manufacturing industry) were in fact shielded from the increasing total labour costs by the restructuring of the industry, resulting in smaller and more efficient firms.

5. Conclusion

The dubious circle of instability and high risks between the airline firms and the aerospace industry demonstrated the speed and seriousness of it, but the firms operating in this business have proved to be rather flexible. This paper analysed one area of the business – labour – which is often in the spotlight of both policy talks and the media from the perspective of industry using total annual payrolls.

The aerospace industry managed to keep the total labour costs steady, but it was not a consequence of decreasing employment while real wages were rising, as one might think – it was rather the result of the underlying changes and restructuring than of anything else. This highlights the impact of management, and possibly also the cuts in the unproductive or inefficient parts and processes. The rise in the real wages in the examined period was not very substantial in the context of its influence on the actual costs (in terms of total payrolls), and it arguably had little effect on the real price of the product. This is good news for airline companies because the aircraft manufacturers managed to keep the real labour costs at bay which, combined with falling interest rates and, thus, cheapening of the capital, can create a market environment for a quick recovery after the current crisis.

One could expect that the industry will successfully accommodate the current epidemic via further fragmentation and efficient restructuring. One can assume that the total employment will be affected rather than total payrolls.

This paper and its results show that the labour analysis is much more complex than a simple, but no doubt intuitive, relationship between wages and total labour costs. It shows that the managerial skills and the market context are of great importance. The study also illustrated the usefulness of the LDMI method for further economic applications where aggregated economic data are concerned.

ANNEXES

Table 1. Cumulative multiplicative effects by sub-sectors

	Nominal				CPI adjusted			
336411	Wage effect	Size effect	No. firms effect	Total effect	Wage effect	Size effect	No. firms effect	Total effect
1	2	3	4	5	6	7	8	9
1999	1.019	0.997	1.002	1.018	1.010	0.997	1.002	1.009
2000	1.017	0.898	1.028	0.939	0.994	0.898	1.028	0.918
2001	1.033	0.887	1.052	0.964	0.999	0.887	1.052	0.932
2002	1.056	0.809	1.074	0.918	1.015	0.809	1.074	0.882
2003	1.055	0.811	1.060	0.907	1.005	0.811	1.060	0.864
2004	1.109	0.803	1.064	0.947	1.045	0.803	1.064	0.892
2005	1.132	0.810	1.062	0.974	1.053	0.810	1.062	0.906
2006	1.151	0.807	1.110	1.031	1.056	0.807	1.110	0.946
2007	1.155	0.766	1.136	1.006	1.047	0.766	1.136	0.912
2008	1.159	0.809	1.100	1.031	1.035	0.809	1.100	0.921
2009	1.175	0.816	1.100	1.055	1.051	0.816	1.100	0.944
2010	1.211	0.766	1.151	1.067	1.075	0.766	1.151	0.948
2011	1.242	0.773	1.136	1.091	1.088	0.773	1.136	0.955
2012	1.249	0.790	1.095	1.081	1.084	0.790	1.095	0.938
336412	Wage effect	Size effect	No. firms effect	Total effect	Wage effect	Size effect	No. firms effect	Total effect
1999	1.008	1.001	1.005	1.014	1.005	1.001	1.005	1.010
2000	1.015	0.990	1.008	1.012	1.006	0.990	1.008	1.003
2001	1.032	0.979	1.010	1.020	1.017	0.979	1.010	1.005
2002	1.021	0.964	1.010	0.994	1.003	0.964	1.010	0.976
2003	1.020	0.948	1.018	0.985	0.998	0.948	1.018	0.964
2004	1.036	0.944	1.018	0.996	1.009	0.944	1.018	0.970

1	2	3	4	5	6	7	8	9
2005	1.036	0.951	1.021	1.005	1.003	0.951	1.021	0.974
2006	1.045	0.941	1.025	1.009	1.007	0.941	1.025	0.971
2007	1.041	0.955	1.027	1.021	0.998	0.955	1.027	0.978
2008	1.047	0.936	1.031	1.010	0.997	0.936	1.031	0.962
2009	1.043	0.931	1.036	1.006	0.994	0.931	1.036	0.958
2010	1.051	0.927	1.036	1.008	0.999	0.927	1.036	0.959
2011	1.062	0.926	1.033	1.015	1.005	0.926	1.033	0.960
2012	1.076	0.937	1.039	1.048	1.015	0.937	1.039	0.988
336413	Wage effect	Size effect	No. firms effect	Total effect	Wage effect	Size effect	No. firms effect	Total effect
1999	1.004	0.987	1.001	0.992	0.999	0.987	1.001	0.987
2000	1.025	0.964	0.996	0.984	1.012	0.964	0.996	0.972
2001	1.028	0.981	0.985	0.994	1.009	0.981	0.985	0.975
2002	1.032	0.995	0.940	0.966	1.008	0.995	0.940	0.944
2003	1.037	0.980	0.925	0.941	1.009	0.980	0.925	0.915
2004	1.052	0.976	0.927	0.952	1.017	0.976	0.927	0.920
2005	1.041	0.997	0.923	0.958	1.000	0.997	0.923	0.920
2006	1.066	0.992	0.928	0.981	1.017	0.992	0.928	0.936
2007	1.072	1.001	0.942	1.011	1.017	1.001	0.942	0.958
2008	1.078	1.013	0.942	1.029	1.013	1.013	0.942	0.966
2009	1.083	1.015	0.939	1.032	1.019	1.015	0.939	0.971
2010	1.087	0.992	0.934	1.008	1.018	0.992	0.934	0.944
2011	1.102	0.998	0.931	1.024	1.025	0.998	0.931	0.953
2012	1.098	1.000	0.943	1.035	1.016	1.000	0.943	0.958
336414	Wage effect	Size effect	No. firms effect	Total effect	Wage effect	Size effect	No. firms effect	Total effect
1999	1.016	0.994	0.994	1.004	1.014	0.994	0.994	1.001
2000	1.018	1.014	0.966	0.997	1.010	1.014	0.966	0.990
2001	1.020	1.005	0.974	0.999	1.009	1.005	0.974	0.988
2002	1.024	1.013	0.950	0.986	1.011	1.013	0.950	0.974
2003	1.014	0.991	0.982	0.987	0.998	0.991	0.982	0.971
2004	1.022	0.931	1.054	1.003	1.002	0.931	1.054	0.983
2005	1.051	0.934	1.017	0.999	1.026	0.934	1.017	0.975
2006	1.028	0.942	1.032	1.000	0.999	0.942	1.032	0.972
2007	1.036	0.950	1.032	1.015	1.003	0.950	1.032	0.983
2008	1.048	0.953	1.032	1.031	1.009	0.953	1.032	0.993
2009	1.041	0.885	1.057	0.973	1.003	0.885	1.057	0.938
2010	1.054	0.897	1.067	1.008	1.014	0.897	1.066	0.970
2011	1.059	0.893	1.063	1.005	1.014	0.893	1.063	0.963
2012	1.064	0.893	1.066	1.013	1.017	0.893	1.066	0.968

Table 1, cont.

1	2	3	4	5	6	7	8	9
336415	Wage effect	Size effect	No. firms effect	Total effect	Wage effect	Size effect	No. firms effect	Total effect
1999	1.001	0.999	1.000	1.001	1.001	0.999	1.000	1.000
2000	1.004	1.003	0.989	0.997	1.002	1.003	0.989	0.994
2001	1.005	1.000	0.992	0.997	1.002	1.000	0.992	0.994
2002	1.006	0.997	0.991	0.994	1.002	0.997	0.991	0.990
2003	1.006	0.992	0.997	0.995	1.001	0.992	0.997	0.990
2004	1.011	0.983	1.003	0.997	1.005	0.983	1.003	0.991
2005	1.012	0.981	1.004	0.997	1.005	0.981	1.004	0.990
2006	1.008	0.990	1.001	0.998	1.000	0.990	1.001	0.990
2007	1.012	0.995	0.998	1.005	1.002	0.995	0.998	0.995
2008	1.011	0.990	1.001	1.002	1.000	0.990	1.001	0.991
2009	1.015	0.992	0.999	1.006	1.004	0.992	0.999	0.995
2010	1.018	0.988	0.998	1.003	1.006	0.988	0.998	0.992
2011	1.017	0.988	0.998	1.002	1.004	0.988	0.998	0.990
2012	1.019	0.985	1.000	1.003	1.005	0.985	1.000	0.990
336419	Wage effect	Size effect	No. firms effect	Total effect	Wage effect	Size effect	No. firms effect	Total effect
1999	1.001	1.000	1.001	1.002	1.001	1.000	1.001	1.002
2000	1.001	1.002	1.000	1.002	1.000	1.002	1.000	1.002
2001	1.002	1.002	0.998	1.002	1.001	1.002	0.998	1.001
2002	1.001	1.001	1.000	1.002	1.000	1.001	1.000	1.001
2003	1.003	1.000	1.003	1.006	1.001	1.000	1.003	1.004
2004	1.006	1.004	1.002	1.012	1.004	1.004	1.002	1.010
2005	1.013	1.018	1.004	1.036	1.010	1.018	1.004	1.033
2006	1.005	1.001	1.004	1.010	1.001	1.001	1.004	1.006
2007	1.006	1.001	1.002	1.010	1.001	1.001	1.002	1.005
2008	1.006	1.000	1.003	1.010	1.001	1.000	1.003	1.004
2009	1.008	1.002	1.003	1.014	1.003	1.002	1.003	1.009
2010	1.008	0.997	1.003	1.008	1.003	0.997	1.003	1.003
2011	1.009	0.995	1.004	1.008	1.003	0.995	1.004	1.002
2012	1.009	0.994	1.004	1.008	1.003	0.994	1.004	1.001

Source: own work.

Table 2. Cumulative additive effects (in $million), by effects and sub-sectors

No. of firms eff.	Nominal						CPI adjusted					
	336411	336412	336413	336414	336415	336419	336411	336412	336413	336414	336415	336419
1	2	3	4	5	6	7	8	9	10	11	12	13
1999	50.7	132.5	33.1	−165.2	0.0	18.5	67.1	175.3	43.7	−218.5	0.0	24.4
2000	731.3	205.8	−117.2	−908.2	−288.8	−9.0	943.9	269.7	−149.8	−1175.4	−372.0	−10.9
2001	1329.5	254.8	−385.1	−711.3	−202.0	−46.2	1690.8	330.9	−484.2	−929.5	−263.5	−57.4
2002	1842.7	254.8	−1534.0	−1314.4	−242.9	5.1	2317.9	330.9	−1888.3	−1666.4	−313.5	5.3
2003	1540.2	450.3	−1909.3	−566.5	−93.6	62.5	1955.3	565.3	−2338.3	−770.0	−134.6	74.0
2004	1611.0	440.2	−1853.9	1074.2	40.6	53.7	2038.2	553.4	−2273.5	1148.9	22.4	63.8
2005	1572.4	514.8	−1976.6	179.9	72.2	97.6	1994.4	638.1	−2412.8	133.5	58.3	113.6
2006	2751.4	623.1	−1824.0	588.1	−27.5	84.5	3289.6	757.1	−2245.1	582.1	−51.3	99.1
2007	3413.5	667.6	−1396.8	588.1	−107.6	51.2	3995.9	804.6	−1789.6	582.1	−136.7	63.6
2008	2466.4	799.2	−1396.8	588.1	−24.3	68.0	3018.5	940.5	−1789.6	582.1	−50.7	80.9
2009	2466.4	941.5	−1506.6	1277.0	−65.7	77.2	3018.5	1084.8	−1901.0	1281.0	−92.7	90.3
2010	3801.0	931.5	−1646.6	1549.9	−109.6	59.4	4364.0	1074.8	−2042.1	1556.0	−137.0	72.3
2011	3413.3	838.1	−1745.6	1447.6	−109.6	102.1	3982.3	982.8	−2139.6	1455.2	−137.0	114.3
2012	2258.3	1023.4	−1342.8	1552.0	−26.9	88.7	2874.0	1160.6	−1753.1	1555.3	−57.6	101.5
Size eff.	336411	336412	336413	336414	336415	336419	336411	336412	336413	336414	336415	336419
1999	−72.1	20.2	−368.5	−171.8	−14.4	12.5	−95.4	26.8	−487.6	−227.3	−19.1	16.5
2000	−2840.7	−277.4	−970.0	363.1	88.5	47.8	−3662.1	−356.4	−1262.2	461.4	113.5	62.0
2001	−3161.9	−555.0	−529.0	144.8	−5.4	40.8	−4063.1	−703.1	−711.5	188.9	−3.8	53.3
2002	−5432.9	−924.7	−172.5	340.1	−83.1	23.3	−6838.5	−1155.0	−275.9	427.5	−98.8	31.8
2003	−5372.8	−1305.6	−519.9	−170.0	−191.6	10.6	−6766.4	−1611.5	−692.4	−184.0	−228.8	16.6
2004	−5613.1	−1405.6	−620.0	−1625.8	−395.0	94.2	−7047.4	−1728.5	−809.6	−1886.5	−466.7	114.3
2005	−5374.0	−1234.5	−85.2	−1536.3	−453.6	458.4	−6776.0	−1534.3	−202.4	−1785.0	−533.3	527.0
2006	−5468.9	−1498.9	−218.7	−1306.2	−209.5	−7.9	−6880.3	−1824.8	−349.1	−1532.0	−265.0	13.4
2007	−6939.9	−1095.4	20.8	−1095.1	−52.3	7.9	−8449.4	−1394.5	−93.6	−1307.0	−97.4	30.3
2008	−5347.9	−1687.5	382.2	−984.4	−210.5	−30.4	−6806.7	−2005.7	279.3	−1192.7	−260.7	−9.4
2009	−5084.3	−1851.3	450.8	−3193.0	−158.7	28.9	−6539.2	−2171.9	348.9	−3433.3	−208.2	50.8
2010	−6974.4	−1978.7	−219.2	−2792.8	−272.3	−116.2	−8444.7	−2300.4	−326.7	−3029.9	−322.7	−95.5
2011	−6689.5	−2012.5	−39.9	−2918.7	−273.0	−188.2	−8164.3	−2333.7	−150.2	−3154.0	−323.3	−166.4
2012	−6009.0	−1617.2	2.5	−2924.9	−382.3	−204.1	−7511.2	−1954.5	−109.5	−3159.9	−428.3	−181.7
Wage eff.	336411	336412	336413	336414	336415	336419	336411	336412	336413	336414	336415	336419
1999	518.9	230.3	112.0	445.0	40.2	23.6	354.9	174.8	−30.3	487.2	21.9	22.7
2000	464.4	405.3	648.9	478.7	110.5	20.8	−174.4	199.0	404.0	380.1	67.7	5.1
2001	863.6	837.1	740.8	530.7	136.2	49.8	−24.9	572.0	308.7	325.2	65.1	29.9
2002	1405.4	557.9	817.0	637.4	163.3	35.2	449.8	143.2	290.2	392.0	79.8	5.8
2003	1389.1	539.7	943.3	407.8	152.9	66.6	187.5	10.2	303.0	31.7	42.3	33.5
2004	2556.1	910.3	1263.7	597.5	272.7	145.8	1262.4	315.1	523.5	149.9	152.4	111.1
2005	3071.8	902.2	1004.1	1306.3	296.9	329.1	1459.8	139.0	31.4	822.4	142.1	287.5
2006	3511.9	1138.8	1640.4	706.8	191.5	112.2	1547.3	239.7	534.9	42.6	−9.1	22.1
2007	3620.3	1033.2	1807.3	913.1	293.4	123.6	1309.6	−16.2	522.5	151.9	65.9	20.6
2008	3706.8	1181.6	1960.7	1265.3	277.5	142.7	940.4	−49.4	407.6	354.7	4.2	22.6

Table 2, cont.

1	2	3	4	5	6	7	8	9	10	11	12	13
2009	4128.4	1070.9	2108.0	1063.7	389.7	200.8	1413.4	−145.2	583.6	162.7	122.3	83.5
2010	5013.7	1293.9	2211.5	1432.6	475.4	196.7	2092.4	4.9	572.4	483.1	189.0	71.3
2011	5774.6	1613.1	2623.7	1557.7	446.9	213.5	2428.4	175.8	766.2	495.0	125.5	75.5
2012	5959.8	2038.6	2513.0	1707.9	504.9	236.8	2337.0	480.4	515.6	566.3	158.3	90.0
Total effect	336411	336412	336413	336414	336415	336419	336411	336412	336413	336414	336415	336419
1999	497.5	383.0	−223.4	108.1	25.7	54.6	326.6	376.9	−474.2	41.4	2.8	63.6
2000	−1645.0	333.7	−438.3	−66.5	−89.8	59.7	−2892.6	112.3	−1008.0	−333.9	−190.7	56.2
2001	−968.8	537.0	−173.3	−35.8	−71.2	44.3	−2397.1	199.8	−887.1	−415.4	−202.2	25.7
2002	−2184.9	−112.0	−889.6	−336.9	−162.7	63.5	−4070.8	−680.8	−1874.0	−846.9	−332.5	42.9
2003	−2443.5	−315.6	−1485.9	−328.7	−132.3	139.7	−4623.6	−1036.1	−2727.7	−922.3	−321.1	124.1
2004	−1446.0	−55.2	−1210.2	45.9	−81.7	293.8	−3746.8	−860.0	−2559.5	−587.7	−291.9	289.3
2005	−729.8	182.5	−1057.8	−50.1	−84.5	885.1	−3321.8	−757.1	−2583.8	−829.1	−332.9	928.1
2006	794.4	263.0	−402.3	−11.2	−45.6	188.8	−2043.4	−828.1	−2059.2	−907.3	−325.5	134.6
2007	93.9	605.4	431.3	406.1	133.4	182.7	−3144.0	−606.2	−1360.8	−573.0	−168.2	114.4
2008	825.3	293.3	946.1	869.0	42.7	180.2	−2847.7	−1114.7	−1102.8	−255.9	−307.2	94.2
2009	1510.5	161.2	1052.3	−852.3	165.3	306.9	−2107.3	−1232.3	−968.5	−1989.7	−178.6	224.6
2010	1840.3	246.6	345.6	189.8	93.5	139.8	−1988.3	−1220.7	−1796.5	−990.9	−270.8	48.0
2011	2498.4	438.6	838.2	86.5	64.3	127.4	−1753.6	−1175.1	−1523.6	−1203.8	−334.9	23.4
2012	2209.1	1444.9	1172.7	335.0	95.7	121.3	−2300.2	−313.5	−1347.1	−1038.3	−327.6	9.7

Source: own work.

Table 3. Cumulative multiplicative effects for aerospace manufacturing industry, by effects

	Nominal				CPI adjusted			
	Wage effect	Size effect	No. firms effect	Total effect	Wage effect	Size effect	No. firms effect	Total effect
1999	1.051	0.978	1.003	1.031	1.029	0.978	1.003	1.009
2000	1.082	0.873	0.985	0.931	1.024	0.873	0.985	0.882
2001	1.127	0.857	1.010	0.975	1.037	0.857	1.010	0.898
2002	1.148	0.785	0.961	0.865	1.040	0.785	0.961	0.784
2003	1.142	0.741	0.981	0.830	1.012	0.741	0.981	0.736
2004	1.257	0.680	1.063	0.909	1.085	0.680	1.063	0.784
2005	1.317	0.717	1.026	0.968	1.099	0.717	1.026	0.808
2006	1.336	0.704	1.094	1.029	1.080	0.704	1.094	0.832
2007	1.359	0.693	1.135	1.069	1.069	0.693	1.135	0.840
2008	1.394	0.724	1.107	1.117	1.056	0.724	1.107	0.846
2009	1.414	0.678	1.133	1.087	1.075	0.678	1.133	0.826
2010	1.496	0.622	1.188	1.106	1.119	0.622	1.188	0.827
2011	1.578	0.627	1.164	1.151	1.144	0.627	1.163	0.834
2012	1.615	0.647	1.149	1.200	1.147	0.647	1.149	0.852

Source: own work.

Table 4. Average wage indices (1998 = 1)

	Nominal						CPI adjusted					
	336411	336412	336413	336414	336415	336419	336411	336412	336413	336414	336415	336419
1998	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1999	1.046	1.052	1.018	1.134	1.038	1.082	1.023	1.030	0.996	1.109	1.015	1.059
2000	1.041	1.092	1.113	1.144	1.110	1.073	0.985	1.034	1.054	1.083	1.050	1.016
2001	1.083	1.195	1.130	1.162	1.139	1.174	0.997	1.100	1.041	1.070	1.048	1.080
2002	1.145	1.124	1.145	1.200	1.171	1.122	1.037	1.019	1.038	1.087	1.061	1.017
2003	1.143	1.119	1.174	1.116	1.158	1.221	1.012	0.992	1.040	0.989	1.026	1.082
2004	1.294	1.223	1.251	1.181	1.310	1.438	1.117	1.056	1.080	1.019	1.131	1.241
2005	1.361	1.221	1.191	1.447	1.342	1.795	1.136	1.019	0.994	1.207	1.121	1.498
2006	1.414	1.286	1.334	1.217	1.210	1.347	1.144	1.040	1.078	0.984	0.978	1.089
2007	1.428	1.258	1.369	1.287	1.325	1.381	1.122	0.989	1.076	1.012	1.042	1.086
2008	1.438	1.298	1.399	1.401	1.307	1.441	1.089	0.982	1.060	1.061	0.990	1.091
2009	1.487	1.267	1.428	1.321	1.437	1.614	1.130	0.962	1.085	1.004	1.092	1.226
2010	1.592	1.330	1.449	1.486	1.543	1.600	1.190	0.994	1.083	1.111	1.154	1.196
2011	1.684	1.424	1.538	1.538	1.506	1.668	1.221	1.032	1.114	1.115	1.091	1.209
2012	1.707	1.544	1.515	1.602	1.583	1.769	1.212	1.096	1.075	1.137	1.124	1.256

Source: own work.

References

Alamdari, F. E., and Morrell, P. (1997). Airline labor cost reduction: post-liberalisation experience in the USA and Europe. *Journal of Air Transport Management*, *3*(2), 53-66.

Albrecht, J., François, D., and Schoors, K. (2002). A Shapley decomposition of carbon emissions without residuals. *Energy Policy*, *30*(9), 727-736.

Alcántara, V., and Duarte, R. (2004). Comparison of energy intensities in European Union countries. Results of a structural decomposition analysis. *Energy Policy*, *32*(2), 177-189.

Anderson, M. (1995). The role of collaborative integration in industrial organization from the Canadian aerospace industry. *Economic Geography*, *71*(1), 55-78.

Ang, B. W. (2004). Decomposition analysis for policymaking in energy: which is the preferred method? *Energy Policy*, *32*(9), 1131-1139.

Ang, B. W., and Liu, F. L. (2001). A new energy decomposition method: perfect in decomposition and consistent in aggregation. *Energy*, *26*(6), 537-548.

Ang, B. W., and Zhang, F. Q. (1999). Inter-regional comparisons of energy-related CO_2 emissions using the decomposition technique. *Energy*, *24*(4), 297-305.

Barros, C. P. (2004). Airports in Argentina: Technical efficiency in the context of an economic crisis. *Journal of Air Transport Management*, (14), 315-319.

Bjelicic, B. (2012). Financing airlines in the wake of the financial markets crisis. *Journal of Air Transport Management*, (21), 10-16.

Butler, H. L. (1967). Aerospace industry revisited. *Financial Analyst Journal*, *23*(5), 57-62.

Butler, H. L., Podrasky, G. J., and Allen, D. J. (1977). The Aerospace Industry Re-Revisited. *Financial Analyst Journal*, *33*(4), 22-35.

Chapman, B. (2015). Waste and duplication in NASA programs: The need to enhance U.S. space program efficiency. *Space Policy*, (31), 13-20.
Chin, A., Hooper, P., and Oum, T. H. (1999). The impacts of the Asian Economic Crises on Asian Airlines: short-run responses and long-run effects. *Journal of Air Transport Management*, (5), 87-96.
Coto-Millan, P., Casares-Hontanon, P., Inglada, V., Agueros, M., Pesquera, M. A., and Badiola, A. (2014). Small is beautiful? The impact of economic crisis, low cost carriers, and the size on efficiency in Spanish airports (2009-2011). *Journal of Air Transport Management*, (40), 34-41.
Cutcher-Gershenfeld, J. (2004). Instability in the aerospace industry. *Perspectives on Work*, *7*(2), 7-9.
De Nooij, M., Van Der Kruk, R., and Van Soest, D. P. (2003). International comparisons of domestic energy consumption. *Energy Economics*, *25*(4), 359-373.
Delgado, L. M. (2011). When inspiration fails to inspire: A change of strategy for the US space program. *Space Policy*, *27*(2), 94-98.
Dietzenbacher, E., and Los, B. (1998). Structural decomposition techniques: sense and sensitivity. *Economic Systems Research*, *10*(4), 307-324.
Dunn, L. F. (1986). Work disutility and compensating differentials: estimation of factors in the link between wages and firm size. *The Review of Economics and Statistics*, *68*(1), 67-73.
Dussauge, P., and Garrette, B. (1995). Determinants of success in international strategic alliances: evidence from the global aerospace industry. *Journal of International Business Studies*, *26*(3), 505--530.
Erickson, Ch. L. (1992). Wage rule formation in the aerospace industry. *Industrial and Labor Relations Review*, *45*(3), 507-522.
Fafchamps, M., and Soderbom, M. (2006). Wages and labor management in African manufacturing. *The Journal of Human Resources*, *41*(2), 346-379.
Ferrall, C. H., and Shearer, B. (1999). Incentives and transaction costs within the firm: estimating an agency model using payroll records. *The Review of Economic Studies*, *66*(2), 309-338.
Ferrer, A., and Lluis, S. (2008). Should workers care about firm size? *Industrial and Labor Relations Review*, *62*(1), 104-125.
Fichtenbaum, R. (2011). Do unions affect labor's share of income: evidence using panel data. *American Journal of Economics and Sociology*, *70*(3), 784-810.
Fisher I. (1967). *The Making of Index Numbers: A Study of Their Varieties, Tests and Reliability*. 3rd edition. New York: A. M. Kelley.
Franke, M., and John, F. (2011). What comes next after the recession? – Airline industry scenarios and potential end games. *Journal of Air Transportation Management*, (17), 19-26.
Goldstein, A. (2002). The political economy of high-tech industries in developing countries: aerospace in Brazil, Indonesia and South Africa. *Cambridge Journal of Economics*, *26*(4), 521-538.
Hajko, V. (2012). Changes in the energy consumption in EU-27 countries. *Review of Economic Perspectives*, *12*(1), 3-21.
Hasegawa, R. (2006). Regional comparisons and decomposition analyses of CO2 emission in Japan. *Environ. Sci*, *19*(4), 277-289.
Hirsch, B. T. (2004). What do unions do for economic performance? *Journal of Labor Research*, *25*(3), 415-455.
Hirsch, B. T., and Macpherson, D. A. (2000). Earnings, rents, and competition in the airline labor market. *Journal of Labor Economics*, *18*(1), 125-155.
Hundley, G. (1993). The effects of comparable worth in the public sector on public/private occupational relative wages. *The Journal of Human Resources*, *28*(2), 318-342.
Huntsinger, G. C. (n.d.). Chapman Burk R and Trainor TE (2012) The US Army projects the effect of merit pay on payroll growth. *Interfaces*, *42*(2), 395-405.
International Energy Agency. (2011). *25 Energy Efficiency Policy Recommendations 2011*. Retrieved from https://webstore.iea.org/25-energy-efficiency-policy-recommendations-2011

Kaps, R. W., Hamilton, J. S., and Bliss, T. J. (2012). *Labor relations in the aviation and aerospace industries*. SIU Press.
Kleiner, M. M., Leonard, J. S., and Pilarski, A. M. (2002). How industrial relations affects plant performance: the case of commercial aircraft manufacturing. *Industrial & Labor Relations Review*, *55*(2), 195-218.
Kugler, A., and Kugler, M. (2009). Labor market effects of payroll taxes in developing countries: evidence from Colombia. *Economic Development and Cultural Change*, *57*(2), 335-358.
Melo Filho, C. R., Salgado, L. H., and Sato, R. C. (2014). Modeling the effects on airline competition under asymmetric economies of density: A case study from Brazil. *Journal of Air Transport Management*, (36), 59-68.
Mitrusi, A., and Poterba, J. (2001). The changing importance of income and payroll taxes on U.S. families. *Tax Policy and the Economy*, (15), 95-119.
Morissette, R. (1993). Canadian jobs and firm size: do smaller firms pay less? *The Canadian Journal of Economics*, *26*(1),159-174.
Morrell, P. (2011). Current challenges in a 'distressed' industry. *Journal of Air Transport Management*, (17), 14-18.
Paarsch, H. J., and Shearer, B. (2000). Piece rates, fixed wages, and incentive effects: statistical evidence from payroll records. *International Economic Review*, *41*(1), 59-92.
Pearce, B. (2012). The state of air transport markets and the airline industry after the great recession. *Journal of Air Transport Management*, (21), 3-9.
Peoples, J. (1990). Airline deregulation and industry wage levels. *Eastern Economic Journal*, *16*(1), 49-58.
Platzer, M. D. (n.d.). *US Aerospace Manufacturing: Industry Overview and Prospects*. Congressional research rept. Library Of Congress Washington DC Congressional Research Service. Accession Number: ADA511133.
Ramey, V. A., and Shapiro, M. D. (2001). Displaced capital: a study of aerospace plant closings. *Journal of Political Economy*, *109*(5), 958-992.
Reinsdorf, M. B., Diewert, W. E. and Ehemann, C. H. (2002). Additive decompositions for Fisher, Törnqvist and geometric mean indexes. *Journal of Economic and Social Measurement*, *28*(1), 51-61.
Rossetti, C. H., and Choi, T. Y. (2005). On the dark side of strategic sourcing: experience from the aerospace industry. *The Academy of Management Executive (1993-2005)*, *19*(1), 46-60.
Shearer, B. (1996). Piece-rates, principal-agent models, and productivity profiles: parametric and semi-parametric evidence from payroll records. *The Journal of Human Resources*, *31*(2), 275-303.
Sleight, S. R., Calhoun, J., and Cutcher-Gershenfeld, J. (2006). The aerospace industry: a focus on skills and capability. *Perspectives on Work*, *9*(2), 50-51.
Sun, J. (1998). Changes in energy consumption and energy intensity: a complete decomposition model. *Energy Economics*, *20*(1), 85-100.
Woods, R. A. (2009). Employment Outlook: 2008-18-Industry Output and Employment Projections to 2018. *Monthly Lab. Rev.*, *132*(52).
Xu, X. Y., and Ang, B. W. (2014). Multilevel index decomposition analysis: Approaches and application. *Energy Economics*, (44), 375-382.