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Abstract

Background: Greater regional devolution can reduce economic inequalities between regions; however, the impact on health inequalities is not clear. We investigated the association between changes over time in the level of devolution in European countries and regional economic and health inequalities.

Methods: We used the proportion of government expenditure controlled by subnational levels of government as our measure of devolution in 14 European countries between 1995 and 2011. Fixed effects linear regression models were used to analyse trends in the level of devolution, trends in regional economic inequalities (Gini-coefficient) and trends in regional health inequalities (slope index) in life expectancy.

Results: Each additional percentage of government expenditure managed at subnational level reduced the Gini-coefficient of regional GDP by -0.17 points (95% CI -0.33 to -0.01; p= 0.04). However, it *increased* the slope index of regional life expectancy by 23 days (95% CI -2 to 48; p=0.07). When trends in regional economic inequalities were controlled for, as a potential mediator - increased devolution - was significantly associated with an *increase* in health inequalities between regions (p=0.01).

Conclusions: Increased devolution does not appear to reduce regional health inequalities – even when it reduces regional economic inequalities - and it could be associated with increased health inequalities.

Introduction

In Europe there has been a growing trend in recent years towards greater devolution, resulting in the delegation of power and resources from central to lower levels of government (1). One key aspect of this devolution has been fiscal devolution where the proportion of public expenditure controlled by subnational levels of government has increased. In the UK for example, substantial powers and resources have been devolved to Scotland and Wales in recent years (2) and giving city regions greater control over resources is central to the UK government's strategy to stimulate economic growth in less economically developed regions (3). In Demark in 2007, large reforms devolved resources and gave additional competences to local and regional authorities (4). The federalism rules introduced in Italy in 2009 increased the fiscal autonomy of the regions (5).

Economic differences between regions are a major cause of health inequalities in Europe, with poorer regions within countries experiencing worse health than more wealthy regions (6). Strategies which reduce these economic inequalities could therefore have a beneficial impact on regional health inequalities.

There are two opposing arguments which indicate the pathways in which fiscal devolution may influence regional economic inequalities. Firstly, it is argued that local decision makers have a greater understanding of local needs, are more accountable to local populations, and have opportunities for innovation, thus devolution can result in more efficient and effective services (7, 8). Where savings are made, resources can be re-invested locally without the inefficiencies that could be introduced by the involvement of central government. Secondly, the opposite argument is fiscal devolution could increase economic inequalities by diminishing the scope of national governments to redistribute resources from wealthier regions to poorer regions (9-11).

The two pathways outlined above also have implications for health inequalities. More effective and efficient local services could help reduce regional health inequalities, whilst reduced redistribution of resources could increase health inequalities (see diagram 1). For example, the Greater Manchester Health and Social Care Devolution Plan proposes to reduce inequalities through redesign of services, including integration across sectors, tailoring to local needs and upgrading prevention (12).

Yet, the relative importance of these two pathways could be different for health inequalities than for economic inequalities. For example, the ability of central governments to target resources at more disadvantaged regions was an effective part of the strategy to reduce health inequalities in England (13, 14). The benefits of this may outweigh those resulting from the increased efficiency and effectiveness that devolution brings. Devolution could also have an impact indirectly through its effect on economic inequalities.

The literature to date relating fiscal devolution to regional inequalities has focused on economic differences between regions, with much of the evidence indicating greater fiscal devolution is associated with reduced economic inequalities between regions (3, 10, 11, 15-17). This suggests, at least for regional economic inequalities, that the increased efficiency

and effectiveness devolution brings outweighs the negative effect from reduced redistribution.

We do not know whether fiscal devolution across Europe has led to either a narrowing or a widening of health differences between regions. The studies which have investigated the health inequalities effect of devolution in high income countries have focused on devolution in health care expenditure and reported equivocal results (18, 19). With 10 to 20% of variations in population health estimated as attributable to the health sector, most differences in health are due to actions in other sectors known to be key determinants of health such as education, employment, environment and housing (20). Therefore, devolution could have positive or negative effects on regional health inequalities through its impact on services across multiple sectors.

In this study, therefore, we used data from a panel of 14 European countries to investigate whether trends in fiscal devolution across European countries are associated with trends in regional health inequalities. We then explored the extent to which changes in regional economic inequalities mediate any effects of fiscal devolution on regional health inequalities.

Method

Setting, data sources and measures

We measured the level of fiscal devolution in each country as the proportion of total government expenditure managed at a subnational level (state, region or local) obtained from the Organisation for Economic Co-operation and Development (OECD) fiscal decentralisation database (21). To measure regional health inequalities, we calculated the slope index of inequality (SII) of regional life expectancy for each country and each year. This measure indicates the absolute difference in life expectancy between the regions with the lowest and highest Gross Domestic Product (GDP) per capita within each country. It was calculated as the population weighted linear regression slope of regional life expectancy and regional GDP per capita, with regional GDP scaled between 0 and 1 (22). Annual data on regional life expectancy and regional GDP per capita were obtained from the OECD for all Territorial Level 2 (TL2) regions within each country. GDP per capita was measured in USD per head, at constant Purchasing Power Parity (PPP) (base year 2010).

The OECD TL2 regions for European countries are the similar to the Eurostat NUTS 2 level classification. We used this level as it represents the first administrative tier of subnational government, and in most European countries this is the level at which fiscal devolution has occurred (5).

To measure regional economic inequality, we calculated the annual Gini-coefficient of regional GDP per capita (23), using the STATA package Inequa7 (24). Using the approach applied by the World Bank (25), we scaled the Gini-coefficient from 0 to 100, with 0 representing perfect equality (meaning all regions have the same GDP) whilst 100 represents complete inequality (one region has all the GDP). To control for national-level economic trends that may confound the effect of devolution on health inequalities (26-28), we included annual data on national GDP and national unemployment rates obtained from the OECD and EUROSTAT respectively (23, 29).

Regions that were autonomous protectorates were excluded (Azores and Madeira in Portugal, and Ceuta and Melilla in Spain). To maximise the generalisability of our analysis to Europe we included all European countries with greater than five regions and with available data between 1995 and 2011. The analysis was therefore based on data from 14 countries: Austria, Czech Republic, Denmark, Finland, France, Germany, Hungary, Italy, Norway, Poland, Portugal, Spain, Sweden, and the UK. For nine countries, data were available for all 17 years between 1995 to 2011 (Austria, Czech Republic, Finland, France, Italy, Portugal, Spain, Sweden, UK). Data were only available for 16 years for Hungary, 15 years for Norway, 12 years for Germany and Denmark and 2 years for Poland. Details of country-years with missing data are given in web Appendix 1. In total, 210 country-years were available for analysis.

Analysis

To explore the data visually, we initially calculated the average absolute annual change in the SII in regional life expectancy, the level of fiscal devolution and the Gini-coefficient of regional GDP. We then graphed scatter-plots of the association between (1) the change in the level of devolution and the change in the Gini-coefficient of regional GDP, and (2) the change in the level of devolution and the change in the SII.

To adjust for the potential confounders of these associations we estimated fixed effects linear regression models, additionally controlling for national economic trends using the annual national GDP and unemployment rate for each country. Fixed effects models essentially include a dummy variable for each country controlling for time-invariant differences between the countries that could act as confounders, so that the models assess the association between absolute trends in devolution and regional economic and health inequalities within countries (30).

Firstly, we included the Gini-coefficient of regional GDP as the outcome and investigated the association between trends in fiscal devolution and the trend in regional economic inequality. Secondly, we included the SII of regional life expectancy as the outcome to investigate the association between trends in fiscal devolution and the trend in regional health inequality. Thirdly, we additionally controlled for the trend in the Gini-coefficient of regional GDP - whilst including the SII of regional life expectancy as the outcome - to explore the extent to which changes in regional economic inequalities mediated the effect of devolution on regional health inequalities. All models were weighted for population size, included time trend terms to adjust for secular trends across Europe, and used robust clustered standard errors. Statistical analyses were performed using STATA11 (full model formulae are given in web Appendix 2).

Sensitivity tests

We undertook several sensitivity tests to investigate the robustness of these models. To exclude any effects from the economic crisis, we limited our analyses to data prior to 2008. Because control over tax revenue - as opposed to control over expenditure - may also be an important indicator of fiscal devolution (31), we replicated our analysis using the proportion of taxation raised at the subnational level as our indicator of fiscal devolution. To take account of delayed effects of changes in devolution, we replicated models with our measure of fiscal devolution lagged by 0 to 3 years. As bias could result from the unbalanced nature of the panel, we repeated analysis only including countries with the full 17 years of data.

Results

Between 1995 and 2011, across the study countries, the average proportion of expenditure controlled by subnational governments increased slightly from 27% to 33% (see web appendix 3). During this time those countries which tended to experience a greater increase in devolution also tended to experience a greater decline in economic differences between regions (as measured by the Gini-coefficient of regional GDP, r=0.29, p=<0.001). However, those countries which experienced a greater increase in devolution also tended to experience a greater *increase* in health inequalities between regions (r=0.47, p=<0.001) (see Figure 1).

The multivariable regression analyses indicated broadly similar associations when controlling for economic trends in each country and country fixed effects. As Table 1 shows, each additional percentage of government expenditure managed at the subnational level reduced the Gini-coefficient of regional GDP by -0.17 points (95% CI -0.33 to -0.01; p= 0.04). With each additional percentage of government expenditure managed at the subnational level the SII of regional life expectancy increased by 23 days (95% CI -2 to 48), although this was just below significance at the 5% level (p=0.07). When additionally controlling for the Gini-coefficient of regional GDP in this model, however, the association increased and was significant (p=0.01). This suggests the association between increased devolution and higher health inequalities was mitigated to some extent through the effect of increased devolution reducing regional economic inequalities. When the mediating pathway between devolution and health inequalities via economic inequalities was held constant (by controlling for it in the analysis), we saw a larger significant association between increased devolution and increased regional health inequalities.

Our results were broadly comparable when limiting data to prior to the economic crisis (2008), or using the proportion of taxation raised at the subnational level as our indicator of fiscal devolution, or only including countries with the full 17 years of data. The lag models indicated that the association between fiscal devolution and reduced economic inequality was greatest for a lag of two years. For the other models, there the association was greatest with the fiscal devolution variable lagged by 1 year (see web Appendix 4).

Discussion

Main findings

As has been the case in previous studies (10, 11) we found increased devolution was associated with reduced regional economic inequalities. However, the impact on health inequalities was not straightforward. We found increases in devolution were associated with *increased* regional health inequalities, although this was only significant if trends in regional economic inequalities were controlled for. This suggests the direct effect of increased devolution was to increase heath inequalities, but because devolution also tended to reduce regional economic inequalities, this mitigated some of the direct negative impacts of devolution on regional health inequalities.

What is already known

There has been a growing trend in Europe towards greater fiscal devolution (1). Several studies have shown greater fiscal devolution is associated with decreased economic inequalities between regions within countries (3, 10, 11, 15-17). It is thought localised decision-making may lead to more effective and efficient use of resources as it is informed by local knowledge about needs and is accountable to local populations and this may contribute to reduced regional economic inequalities (9).

We do not know the health inequalities impact of devolution policy. The few studies which have investigated the health inequalities effect of devolution in high income countries have tended to investigate the effects of devolution on health care expenditure. An Italian study (32), found a reform which devolved a large proportion of healthcare expenditure was associated with a reduction in inequalities in self-reported health *within* regions, but it did not investigate the effect on inequalities between regions. Costa-Font & Gil (18) found no association between devolution of health care expenditure in Spain and inequalities in reported health status. A Canadian study found healthcare devolution was followed by an increase in inequalities in health status (19). However, although we know public investment across multiple sectors (education, employment, environment and housing) has the potential to influence health, we do not know whether increased fiscal devolution of public expenditure in general is associated with a decrease or an increase in health differences between regions within European countries.

What this study adds

Our results indicate that whilst devolution may be an effective approach to reducing regional economic inequalities, this does not necessarily translate into reduced health inequalities. In fact, the opposite may be true, and devolution may increase health inequalities between regions. There are several reasons why fiscal devolution could be associated with reduced regional differences in GDP whilst being associated with increased regional differences in life expectancy.

Firstly, it could be that the ability to redistribute resources from wealthier regions to poorer regions is particularly important for addressing health inequalities and this capacity is reduced in more devolved administrations, leading to under-funded health and social services in poorer regions. Other research has shown that centrally-planned targeting of resources to disadvantaged areas has been associated with reduced health inequalities (13, 14).

Secondly, greater local control over public investment decisions may lead to local legislation and investment in projects which have primarily economic benefits and limited health benefits. Investment in infrastructure projects, attracting outside investment or public popularity may be prioritised above health; and thus, economic efficiencies may not translate into population health benefits. Local governments may also be more susceptible to lobbying from corporations and local businesses, undermining their capacity to implement public health legislation – such as controlling access to alcohol or unhealthy foods, or reducing environmental pollution. Whilst local businesses may seek to reduce regulations that have public health benefits but are seen as a barrier to economic growth (33).

Finally, it could also be that the reductions in regional differences in GDP associated with increased fiscal devolution do not represent a reduction in inequalities in the life chances of the populations living in different regions. For example, in more devolved administrations where there is greater regional control over the setting of tax rates, poorer regions may try and compete with other regions to attract external investment by reducing taxes. This could lead to increased capital flows into poorer regions – reducing regional differences in GDP, however these increases in regional GDP may not translate into widespread improvements in wages (34). Furthermore the reduced levels of taxation in these regions then reduce income for public service provision, further widening inequalities in life chances. (35).

Our findings have important implications for policies that aim to devolve greater resources to subnational levels. They indicate that even if such policies reduce economic differences between regions, they could still increase health differences. Therefore, policies should not be purely focused on economic growth or even just on reducing economic inequalities between regions. Mitigating actions will need to be taken to ensure heath inequalities are not increased by these policies and to maximise the potential for such policies to reduce health inequalities (36).

Strengths and limitations of this study

Our findings need to be understood in the context of several limitations. Firstly, because our study analysed data at the aggregate level, we cannot know whether the findings reflect associations at the individual level. For example, it could be that whilst there was an association between increased devolution and increased regional health inequalities, health inequalities could have concurrently reduced within regions as was found in the study of health care devolution in Italy (32).

Secondly, the measure of devolution we used – the proportion of government expenditure managed at the subnational level - only reflects a component of devolution. In practice, the nature of devolution differs greatly between countries, with differences in the level of devolution between tiers of government and between regions. Models vary between federal governments with three tiers, such as Belgium, to unitary governments with one level but with some autonomous regions, such as in Portugal (37). In some countries, devolution relates primarily to decisions over expenditure, in others to tax raising powers, and in others to legislative freedoms. In this study, we have focused on one measure of fiscal devolution, and we have not been able to investigate differential impacts of alternative approaches to devolution across the study countries. However, our findings did not change when using the proportion of tax revenue raised at the subnational level (rather than the level of expenditure controlled at the subnational level) as the measure of devolution.

Thirdly, due to limitations in the data available the sample size was relatively small; therefore, the analysis may have been underpowered and our estimates are relatively imprecise. Fourthly, it is possible the associations we observed were due to other

confounding factors that we were not able to take into account in the analysis. However, by analysing change over time across countries, our analysis provides more robust evidence than simple cross-sectional analyses. This enabled us to control for potentially unobserved time-invariant confounders that could vary between countries. Finally, our investigation of whether regional economic inequalities mediate the effect of fiscal devolution on regional health inequalities assumes trends in regional health inequalities are not a major cause of regional economic inequalities. If this was the case, we would be conditioning on a common effect of exposure and outcome and the increased association observed in model 3 could then be the result of collider bias (38).

Conclusion

Across the 14 European countries included in our analysis, whilst increased fiscal devolution was associated with decreased regional economic inequalities, it was associated with increased regional health inequalities. Policies which promote increased fiscal devolution should aim to minimise any negative impacts on health inequalities and to maximise positive impacts. This could include ensuring that devolution is combined with policies for inclusive economic growth (39) and a progressive system for redistribution of resources both between regions and between individuals through a comprehensive welfare system (22).

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In Europe there has been a growing trend in recent years towards greater devolution, resulting in the delegation of power and resources from central to lower levels of government (1). One key aspect of this devolution has been fiscal decentralisation where the proportion of public expenditure controlled by subnational levels of government has increased. In the UK for example, substantial powers and resources have been devolved to Scotland and Wales in recent years (2) and giving city regions greater control over resources is central to the UK government's strategy to stimulate economic growth in less economically developed regions(3). In Demark in 2007, large reforms ~~decentralised~~ devolved resources and gave additional competences to local and regional authorities (4). The federalism rules introduced in Italy in 2009 increased the fiscal autonomy of the regions (5).

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~~Most differences in health between populations are not due to actions in the health sector, but due to actions in other sectors known to be key determinants of health – e.g education, employment, environment and housing, with only around 10 to 20% of variations in population health estimated to be attributable to the health sector. Therefore, devolution~~

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Comment [BB4]: [this is a better reference - "The Relative Contribution of Multiple Determinants to Health, " Health Affairs Health Policy Brief, August 21, 2014. DOI: 10.1377/hpb20140821.404487].

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~~could have positive or negative effects of regional health inequalities through its effect on services across multiple sectors.~~

~~Given health services account for only a third of the impact on life expectancy(21), focusing on health service devolution misses the influence of fiscal devolution on services as education, employment and housing.~~

~~The relative importance of these two pathways could be different for health inequalities than for economic inequalities. For example, the ability of central governments to target resources at more disadvantaged regions was an effective part of the strategy to reduce health inequalities in England (16, 17). The benefits of this may outweigh those resulting from the increased efficiency and effectiveness that devolution brings.(21)~~

~~Fiscal devolution could have an impact on health inequalities directly through the health benefits of improved health and social services, and it could also have an impact indirectly through its effect on economic inequalities, which are known determinants of health (see Appendix 4 for a diagram outlining the pathways from fiscal devolution to regional health inequalities).~~

In this study, therefore, we used data from a panel of 14 European countries to investigate whether trends in fiscal devolution across European countries are associated with trends in regional health inequalities. We then explored the extent to which changes in regional economic inequalities mediate any effects of fiscal devolution on regional health inequalities.

Method

Setting, data sources and measures

We measured the level of fiscal devolution in each country as the proportion of total government expenditure managed at a subnational level (state, region or local) obtained from the Organisation for Economic Co-operation and Development (OECD) fiscal decentralisation database (22). To measure regional health inequalities, we calculated the slope index of inequality (SII) of regional life expectancy for each country and each year. This measure indicates the absolute difference in life expectancy between the regions with the lowest and highest Gross Domestic Product (GDP) per capita within each country. It was calculated as the population weighted linear regression slope of regional life expectancy and

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regional GDP per capita, with regional GDP scaled between 0 and 1 (23). Annual data on regional life expectancy and regional GDP per capita were obtained from the OECD for all Territorial Level 2 (TL2) regions within each country. GDP per capita was measured in USD per head, at constant Purchasing Power Parity (PPP) (base year 2010).

The OECD TL2 regions for European countries are the similar to the Eurostat NUTS 2 level classification. We used this level as ~~this~~ it represents the first administrative tier of subnational government, and in most European countries this is the level ~~to~~ at which fiscal devolution has occurred (5).

To measure regional economic inequality, we calculated the annual Gini-coefficient of regional GDP per capita (24), using the STATA package Inequa7 (25). Using the approach applied by the World Bank (26), we scaled the Gini-coefficient from 0 to 100, with 0 representing perfect equality (meaning all regions have the same GDP) whilst 100 represents complete inequality (one region has all the GDP). To control for national-level economic trends that may confound the effect of devolution on health inequalities (27-29), we included annual data on national GDP and national unemployment rates obtained from the OECD and EUROSTAT respectively (24, 30).

Regions that were autonomous protectorates were excluded (Azores and Madeira in Portugal, and Ceuta and Melilla in Spain). To maximise the generalisability of our analysis to Europe we included all European countries with greater than five regions and with available data between 1995 and 2011. The analysis was therefore based on data from 14 countries: Austria, Czech Republic, Denmark, Finland, France, Germany, Hungary, Italy, Norway, Poland, Portugal, Spain, Sweden, and the UK. For nine countries, data were available for all 17 years between 1995 to 2011 (Austria, Czech Republic, Finland, France, Italy, Portugal, Spain, Sweden, UK). Data were only available for 16 years for Hungary, 15 years for Norway, 12 years for Germany and Denmark and 2 years for Poland. Details of country-years with missing data are given in Appendix 1. In total, 210 country-years were available for analysis.

Analysis

To explore the data visually, we initially calculated the average absolute annual change in the SII in regional life expectancy, the level of fiscal devolution and the Gini-coefficient of

regional GDP. We then graphed scatter-plots of the association between (1) the change in the level of devolution and the change in the Gini-coefficient of regional GDP, and (2) the change in the level of devolution and the change in the SII.

To adjust for the potential confounders of these associations we estimated fixed effects linear regression models, additionally controlling for national economic trends using the annual national GDP and unemployment rate for each country. Fixed effects models essentially include a dummy variable for each country controlling for time-invariant differences between the countries that could act as confounders, so that the models assess the association between absolute trends in devolution and regional economic and health inequalities within countries (31).

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Firstly, we included the Gini-coefficient of regional GDP as the outcome and investigated the association between trends in fiscal devolution and the trend in regional economic inequality. Secondly, we included the SII of regional life expectancy as the outcome to investigate the association between trends in fiscal devolution and the trend in regional health inequality. Thirdly, we additionally controlled for the trend in the Gini-coefficient of regional GDP - whilst including the SII of regional life expectancy as the outcome - to explore the extent to which changes in regional economic inequalities mediated the effect of devolution on regional health inequalities. All models were weighted for population size, included time trend terms to adjust for secular trends across Europe, and used robust clustered standard errors. Statistical analyses were performed using STATA11 (full model formulae are given in Appendix 2).

Sensitivity tests

We undertook several sensitivity tests to investigate the robustness of these models. To exclude any effects from the economic crisis, we limited our analyses to data prior to 2008. Because control over tax revenue - as opposed to control over expenditure - may also be an important indicator of fiscal devolution (32), we replicated our analysis using the proportion of taxation raised at the subnational level as our indicator of fiscal devolution. To take account of delayed effects of changes in devolution, we replicated models with our measure of fiscal devolution lagged by 0 to 3 years. As bias could result from the unbalanced nature of the panel, we repeated analysis only including countries with the full 17 years of data.

Results

Between 1995 and 2011, across the study countries, the average proportion of expenditure controlled by subnational governments increased slightly from 27% to 33%. During this time those countries which tended to experience a greater increase in devolution also tended to experience a greater decline in economic differences between regions (as measured by the Gini-coefficient of regional GDP, r=0.29, p=<0.001). However, those countries which experienced a greater increase in devolution also tended to experience a greater *increase* in health inequalities between regions (r=0.47, p=<0.001) (see Figure 1).

The multivariable regression analyses indicated broadly similar associations when controlling for economic trends in each country and country fixed effects. As Table 1 shows, each additional percentage of government expenditure managed at the subnational level reduced the Gini-coefficient of regional GDP by -0.17 points (95% CI -0.33 to -0.01; p= 0.04). With each additional percentage of government expenditure managed at the subnational level the SII of regional life expectancy increased by 23 days (95% CI -2 to 48), although this was just below significance at the 5% level (p=0.07). When additionally controlling for the Gini-coefficient of regional GDP in this model, however, the association increased and was significant (p=0.01). This suggests the association between increased devolution and higher health inequalities was mitigated to some extent through the effect of increased devolution reducing regional economic inequalities. When the mediating pathway between devolution and health inequalities via economic inequalities was held constant (by controlling for it in the analysis), we saw a larger significant association between increased devolution and increased regional health inequalities.

Our results were broadly comparable when limiting data to prior to the economic crisis (2008), or using the proportion of taxation raised at the subnational level as our indicator of fiscal devolution, or only including countries with the full 17 years of data. The ~~distributed~~ lag models indicated that the association between fiscal devolution and reduced economic inequality was greatest for a lag of two years. For the other models, there the association was greatest with the fiscal devolution variable lagged by 1 year (see Appendix 4).

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Discussion

Main findings

As has been the case in previous studies (7, 11) we found increased devolution was associated with reduced regional economic inequalities. However, the impact on health inequalities was not straightforward. We found increases in devolution were associated with *increased* regional health inequalities, although this was only significant if trends in regional economic inequalities were controlled for. This suggests the direct effect of increased devolution was to increase heath inequalities, but because devolution also tended to reduce regional economic inequalities, this mitigated some of the direct negative impacts of devolution on regional health inequalities.

What is already known

There has been a growing trend in Europe towards greater fiscal devolution (1) . Several studies have shown that greater fiscal devolution is associated with ~~and this has led to~~ decreased economic inequalities between regions within countries (3, 7-11). ~~-~~It is ~~thought~~thought ~~to be because more~~ that localised decision-making may leads ~~to~~ more effective and efficient use of resources as it is informed by local knowledge about needs and is accountable to local populations and that this may contribute to reduced regional economic inequalities~~.~~ (15). ~~These benefits appear to outweigh any negative effects fiscal devolution may have on regional economic inequalities.~~

We do not know the health inequalities impact of ~~this~~ devolution ~~policy~~ ~~-~~policy. The few studies which have investigated the health inequalities effect of devolution in high income countries have tended to investigate the effects of devolution on~~f~~ health care expenditure. An Italian study (33), found a reform which devolved a large proportion of healthcare expenditure was associated with a reduction in inequalities in self-reported health *within* regions, but it did not investigate the effect on inequalities between regions. Costa-Font & Gil (18) found no association between devolution of health care expenditure in Spain and inequalities in reported health status. A Canadian study found healthcare devolution was followed by an increase in inequalities in health status (19). However, although we know ~~that~~ public investment across multiple sectors (education, employment, environment and

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Comment [BB5]: We have never suggested devolution has a negative effect on wealth redistribution – we have suggested it might have a negative effect on the redistribution of public resources for services – this is something very different from wealth. And we don't even know if that is true – its just a hypothesis – so not already known.

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housing~~health, education, housing, employment~~) has the ~~we~~potential to influence health, we do not know whether increased fiscal devolution of public expenditure in general ~~across Europe is~~ is associated with a decrease or an increase in health differences between regions within European countries. ~~-~~

What this study adds

Our results indicate that whilst devolution may be an effective approach to reducing regional economic inequalities, this does not necessarily translate into reduced health inequalities. In fact, the opposite may be true, and devolution may increase health inequalities between regions. There are several reasons why fiscal devolution could be ~~is~~ associated with reduced regional differences in GDP whilst being associated with increased regional differences in life expectancy.

Firstly, it could be that the ability to redistribute resources from wealthier regions to poorer regions is particularly important for addressing health inequalities - and this capacity is reduced in more devolved administrations, leading to under-funded health and social services in poorer regions. Other research has shown that centrally-planned targeting of resources to disadvantaged areas has been associated with reduced health inequalities (16, 17).

Secondly, greater local control over public investment decisions may lead to local legislation and investment in projects ~~that~~ which have primarily economic benefits and limited health benefits. Investment in infrastructure projects, attracting outside investment or public popularity may be prioritised above health; and thus, economic efficiencies may not translate into population health benefits. ~~, such as infrastructure projects, which do not translate into population health benefits.~~ Local governments may also be more susceptible to lobbying from corporations and local businesses, undermining their capacity to implement public health legislation – such as ~~that~~ controlling access to alcohol or unhealthy foods, or reducing environmental pollution. Whilst local businesses may seek to reduce regulations ~~that~~that have public health benefits but are seen as a barrier to economic growth~~.~~ (34). ~~There is also evidence local areas may be susceptible to the power of corporations who are have more resources at their disposal to be able to overturn local public health decisions.~~(34)~~.~~

Finally, it could also be that the reduction in regional differences in GDP that are associated with increased fiscal devolution do not represent a reduction in inequalities in the life chances

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of the populations living in different regions. For example, in more devolved administrations where there is greater regional control over the setting of tax rates, poorer regions may try and compete with other regions to attract external investment by reducing taxes. This could lead to increased capital flows into poorer regions – reducing regional differences in GDP~~.~~, however these increases in regional GDP may not translate into widespread improvements in wages (35). Furthermore the reduced levels of taxation in these regions then ~~Greater competition for business between regions could~~ reduce income for public service provision, further widening inequalities in life chances. ~~. There may also be regions which struggle more to attract investment, for example rural areas without transport connectivity~~ (36). ~~There is also evidence local areas may be susceptible to the power of corporations who are have more resources at their disposal to be able to overturn local public health decisions~~ (34)~~.~~ ~~. However, this may increase economic inequalities within regions and could reduce the resources available for public investment in health and social services~~ (35)~~.~~

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Our findings have important implications for policies that aim to devolve greater resources to subnational levels. They indicate that even if such policies reduce economic differences between regions, they could still increase health differences. Therefore, policies should not be purely focused on economic growth or even just on reducing economic inequalities between regions. Mitigating actions will need to be taken to ensure heath inequalities are not increased by these policies and to maximise the potential for such policies to reduce health inequalities (37).

Strengths and limitations of this study

Our findings need to be understood in the context of several limitations. Firstly, because our study analysed data at the aggregate level, we cannot know whether the findings reflect associations at the individual level. For example, it could be that whilst there was an association between increased devolution and increased regional health inequalities, health inequalities could have concurrently reduced within regions as was found in the study of health care devolution in Italy (33).

Secondly, the measure of devolution we used – the proportion of government expenditure managed at the subnational level - only reflects a component of devolution. In practice, the nature of devolution differs greatly between countries, with differences in the level of

devolution between tiers of government and between regions. Models vary between federal governments with three tiers, such as Belgium, to unitary governments with one level but with some autonomous regions, such as in Portugal (38). In some countries, devolution relates primarily to decisions over expenditure, in others to tax raising powers, and in others to legislative freedoms. In this study, we have focused on one measure of fiscal devolution, and we have not been able to investigate differential impacts of alternative approaches to devolution across the study countries. However, our findings did not changed when using the proportion of tax revenue raised at the subnational level (rather than the level of expenditure controlled at the subnational level) as the measure of devolution.

Thirdly, due to limitations in the data available the sample size was relatively small; therefore, the analysis may have been underpowered and our estimates are relatively imprecise. Fourthly, it is possible the associations we observed were due to other confounding factors that we were not able to take into account in the analysis. However, by analysing change over time across countries, our analysis provides more robust evidence than simple cross-sectional analyses. This enabled us to control for potentially unobserved time-invariant confounders that could vary between countries. Finally, our investigation of whether regional economic inequalities mediate the effect of fiscal devolution on regional health inequalities assumes trends in regional health inequalities are not a major cause of regional economic inequalities. If this was the case, we would be conditioning on a common effect of exposure and outcome and the increased association observed in model 3 could then be the result of collider bias (39).

Conclusion

Across the 14 European countries included in our analysis, whilst increased fiscal devolution was associated with decreased regional economic inequalities, it was associated with increased regional health inequalities. Policies which promote increased fiscal devolution should aim to minimise any negative impacts on health inequalities and to maximise positive impacts. This could include ensuring that devolution is combined with policies for inclusive economic growth (40) and a progressive system for redistribution of resources both between regions and between individuals through a comprehensive welfare system (23).

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Diagram 1. Logic model relating fiscal devolution to regional economic inequalities and regional health inequalities.

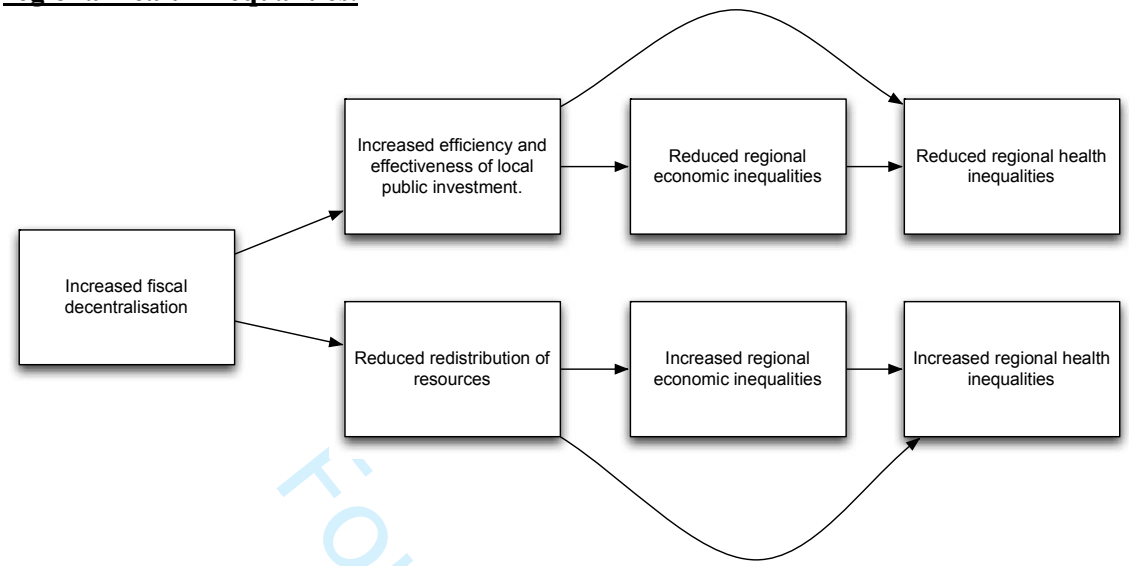
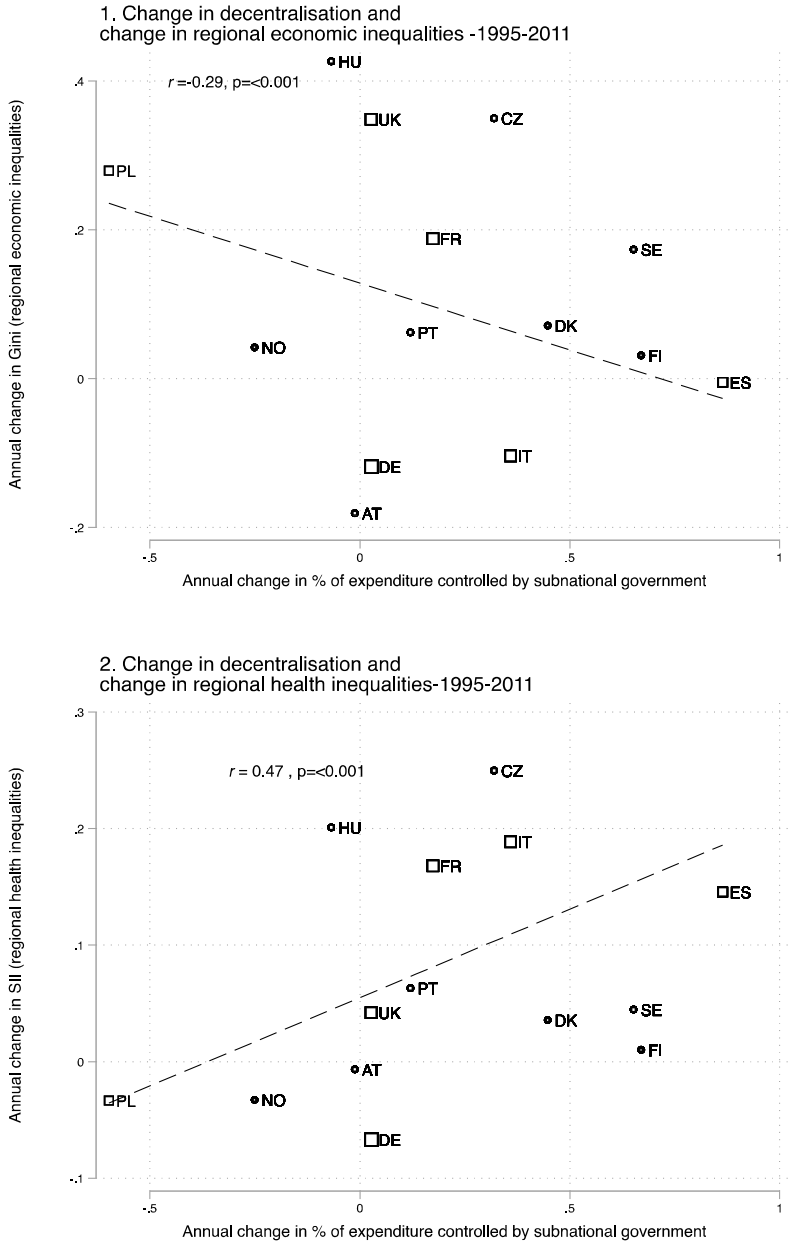


Figure 1: Scatter plots showing the association between the average annual change in the level of devolution in each country and (1) the average annual change in regional economic inequalities and (2) the average annual change in regional health inequalities. Number of years included on the analysis for each country shown in key below.



Key: AT – Austria (17yrs), CZ – Czech Republic (17yrs), DE – Germany (12 yrs), DK – Denmark (12 yrs), FI – Finland (17yrs), FR – France (17yrs), ES – Spain (17yrs), HU – Hungry (16yrs), IT – Italy (17yrs), NO – Norway (15yrs), PL – Poland (2yrs), PT – Portugal (17yrs), SE – Sweden (17yrs), UK – United Kingdom (17yrs).

Table 1: Association between increased devolution and change in regional economic inequalities (model 1) and regional health inequalities (model 2). Model 3 shows change in regional health inequalities associated with increased devolution, when controlling for change in regional economic inequalities.

	Model	Coefficient	95%CI		p-value
Change in regional Gini for each additional 1% of expenditure controlled at the subnational level.	1	-0.17	-0.33	-0.01	0.04
Change in SII (in years of life expectancy) for each additional 1% of expenditure controlled at the subnational level.	2	23.28	-1.67	48.23	0.07
Change in SII (in years of life expectancy) for each additional 1% of expenditure controlled at the subnational level. (Additionally controlling for regional Gini).	3	31.95	7.37	56.53	0.01

Note: Models based on equations C shown in online supplementary appendix 2 and included controls for country fixed effects, time trends, national unemployment rate and national GDP, full model results are given in online supplementary appendix 3).

Appendix 1. Web table 1. Number of observations and minimum and maximum values

Number of observations and minimum and maximum values				
Variable	Number of observations	Number of values	Min	Max
year	210	17	1995	2011
proportion of devolution	210	210	11.56663	62.90967
Total expenditure	203	203	18683.8	1215270
percentage unemployed	210	93	2.5	21.4
national population	210	210	4405156	82500000
national GDP	210	209	11718	49396
number of regions	210	11	5	22
Slope Index of regional life expectancy	210	210	-2.087478	6.439848
Gini of regional GDP	210	210	7.212533	22.75613
total public expenditure	203	203	1811.984	31690.29

Appendix 2. Model formula.

Model formula.

Specifically we estimated the following models:

Model1: $GINI_{i,t} = \beta_1 DEVOL_{,I,t} + \beta_2\ NATUNEMP_{,I,t} + \beta_3\ NATGDP_{,I,t} + \beta_4\ YEAR + CONS + \mu_i + \varepsilon_{i,t}$

Model2: $SII_{i,t} = \beta_1 DEVOL_{,I,t} + \beta_2\ NATUNEMP_{,I,t} + \beta_3\ NATGDP_{,I,t} + \beta_4 YEAR + CONS + \mu_i + \varepsilon_{i,t}$

Model2: $SII_{i,t} = \beta_1 DEVOL_{,I,t} + \beta_2\ GINI_{i,t} + \beta_3\ NATUNEMP_{,I,t} + \beta_4\ NATGDP_{,I,t} + \beta_5 YEAR + CONS + \mu_i + \varepsilon_{i,t}$

Where GINI is the Gini coefficient of regional gdp in country i in year t

DEVOL is the proportion of government expenditure managed at the sub regional level in country i in year t

NATUNEMP is the national unemployment rate in country i in year t

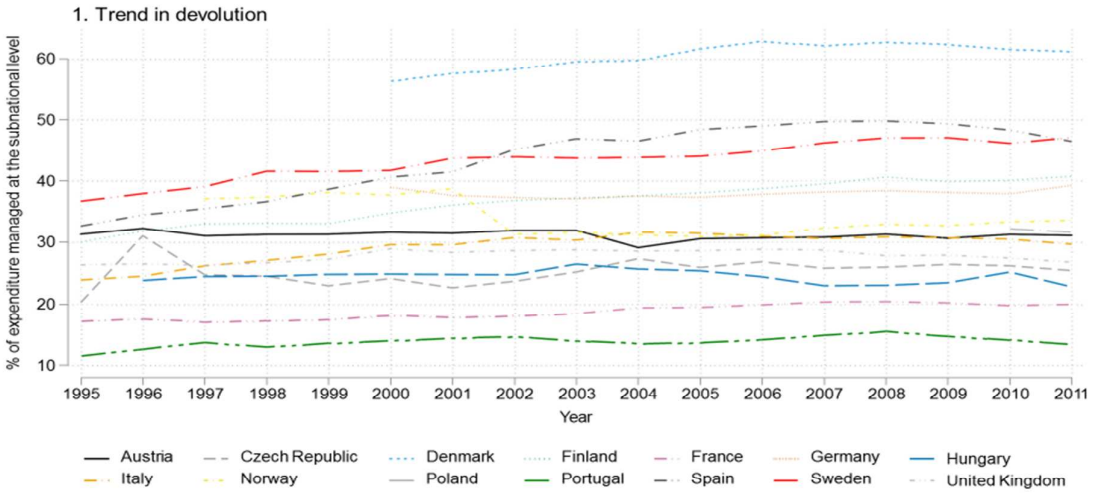
NATGDP is the national GDP per capita in country i in year t

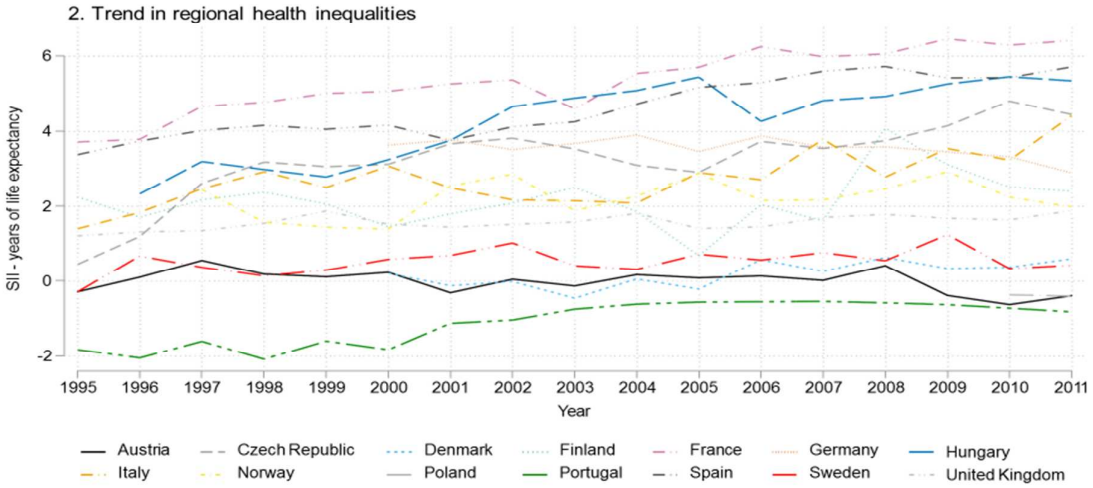
CONS is a constant.

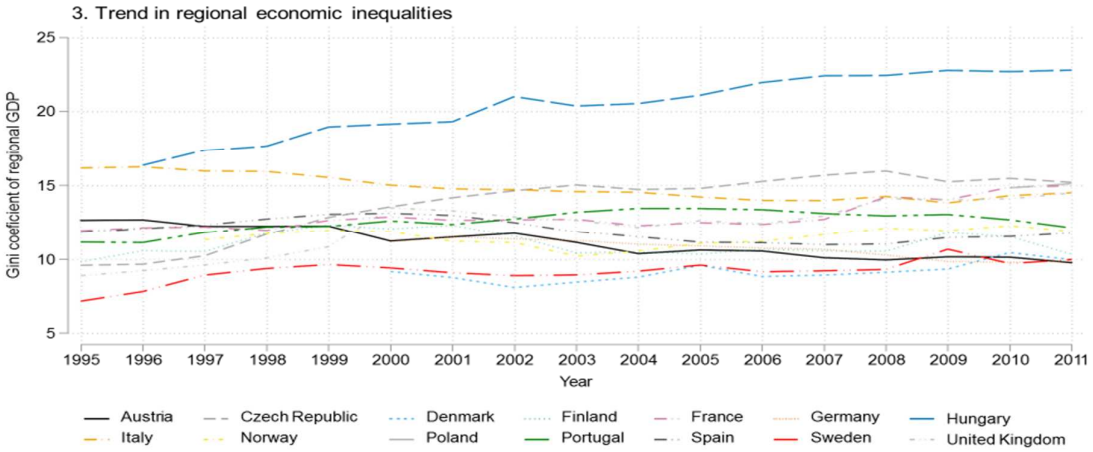
μ_i is a fixed effect for each country i

$\varepsilon_{i,t}$ is an error term

Appendix 3. Trends in devolution, regional health inequalities and regional economic inequalities.







Appendix 4: Sensitivity tests

We undertook several sensitivity tests to investigate the robustness of these models, including controls for total government expenditure, and only including countries with the full 17 years of data. These models showed broadly comparable results (see appendix 4).

Web table 2: Limiting analysis to period prior to the economic crisis (2008) - association between increased devolution and change in regional economic (model 1) and health (model 2) inequalities. Model 3 shows change in health inequalities associated with increased devolution, when controlling for change in economic inequalities.

	Model	Coefficient	95%CI		p-value
Change in regional Gini for each additional 1% of expenditure controlled at the subnational level.	1	-0.17	-0.32	-0.01	0.04
Change in SII (in days of life expectancy) for each additional 1% of expenditure controlled at the subnational level.	2	15.85	-6.33	38.03	0.15
Change in SII (in days of life expectancy) for each additional 1% of expenditure controlled at the subnational level. (Additionally controlling for regional Gini).	3	22.77	-0.25	45.79	0.05

Note: Models based on equations shown in online supplementary appendix 2 and included controls for country fixed effects, time trends, national unemployment rate and national GDP, full model results are given in online supplementary appendix 3).

Web table 3: Only including countries with the full 17 years of data. - Association between increased devolution and change in regional economic (model 1) and health (model2) inequalities. Model 3 shows change in health inequalities associated with increased devolution, when controlling for change in economic inequalities.

	Model	Coefficient	95%CI		p-value
Change in regional Gini for each additional 1% of expenditure controlled at the subnational level.	1	-0.24	-0.35	-0.13	0
Change in SII (in years of life expectancy) for each additional 1% of expenditure controlled at the subnational level.	2	16.6	-5.74	38.94	0.12
Change in SII (in years of life expectancy) for each additional 1% of expenditure controlled at the subnational level. (Additionally controlling for regional Gini).	3	21.42	2.41	40.43	0.03

Note: Models based on equations shown in online supplementary appendix 2 and included controls for country fixed effects, time trends, national unemployment rate and national GDP, full model results are given in online supplementary appendix 3).

Web table 4: Including controls for total government expenditure - association between increased devolution and change in regional economic (model 1) and health (model2) inequalities. Model 3 shows change in health inequalities associated with increased devolution, when controlling for change in economic inequalities.

	Model	Coefficient	95%CI		p-value
Change in regional Gini for each additional 1% of expenditure controlled at the subnational level.	1	-0.16	-0.32	0.01	0.06
Change in SII (in years of life expectancy) for each additional 1% of expenditure controlled at the subnational level.	2	24.27	-5.34	53.87	0.1
Change in SII (in years of life expectancy) for each additional 1% of expenditure controlled at the subnational level. (Additionally controlling for regional Gini).	3	33.65	8.1	59.19	0.01

Note: Models based on equations shown in online supplementary appendix 2 and included controls for country fixed effects, time trends, national unemployment rate and national GDP, full model results are given in online supplementary appendix 3).

Web table 5: Changing the devolution variable to subnational tax revenue - association between increased devolution and change in regional economic (model 1) and health (model2) inequalities. Model 3 shows change in health inequalities associated with increased devolution, when controlling for change in economic inequalities.

	Model	Coefficient	95%CI		p-value
Change in regional Gini for each additional 1% of expenditure controlled at the subnational level.	1	-0.14	-0.22	-0.06	<0.01
Change in SII (in years of life expectancy) for each additional 1% of expenditure controlled at the subnational level.	2	14.29	-5.15	33.73	0.14
Change in SII (in years of life expectancy) for each additional 1% of expenditure controlled at the subnational level. (Additionally controlling for regional Gini).	3	22	0.7	43.3	0.04

Appendix 5: Values of fiscal devolution (percentage of expenditure managed at the sub national level) by country.

Web table 6: Including a fiscal devolution variable lagged by 0,1,2 and 3 years- association between increased devolution and change in regional economic (model 1) and health (model2) inequalities. Model 3 shows change in health inequalities associated with increased devolution, when controlling for change in economic inequalities.

country	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Austria	31	32	31	31	31	32	31	32	32	29	31	31	31	31	31	31	31
Czech Republic	20	31	25	25	23	24	23	24	25	27	26	27	26	26	26	26	25
Denmark						56	58	58	60	60	62	63	62	63	62	62	61
Finland	30	32	33	33	33	35	36	37	37	38	38	39	40	41	40	40	41
France	17	18	17	17	18	18	18	18	19	19	20	20	20	20	20	20	20
Germany						39	38	37	37	38	37	38	38	38	38	38	39
Hungary		24	24	25	25	25	25	25	26	26	25	24	23	23	23	25	23
Italy	24	25	26	27	28	30	30	31	30	32	31	31	31	31	31	30	30
Norway			37	37	38	38	39	31	32	31	31	31	32	33	33	33	34
Poland																32	32
Portugal	12	13	14	13	14	14	14	15	14	14	14	14	15	16	15	14	13
Spain	33	34	35	37	39	41	41	45	47	47	48	49	50	50	49	48	46
Sweden	37	38	39	42	42	42	44	44	44	44	44	45	46	47	47	46	47
United Kingdom	26	27	26	27	27	29	28	29	29	29	29	29	29	28	28	27	27