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The Economic Aftermath of Institutions

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In loving memory of Gregoria and Ángel,
Miguel Ángel and Bill.

Summary

This thesis gathers four chapters that span the fields of political economy, comparative politics and institutional economics. The first chapter, "The Growth Effect of Democracy and Technology: an Industry Disaggregated Approach" tackles the everlasting query of whether or not democracy promotes economic growth, and contributes by highlighting the importance of technological change. I propose a disaggregated manufacturing approach to study whether democracy has an effect on the economic performance of industries, and if so, whether this effect hinge upon technological change. A panel dataset of 61 manufacturing industries from 72 countries between 1990 and 2010 is constructed, along with the use of various indices of democracy. The World Technological Frontier (WTF) is used as a measure of technological development within industries—the closer the industries to the WTF, the more technologically advanced. The results suggest that the effect of democracy is technologically-conditioned. Changes towards democracy are growth-enhancing for industries close to the WTF but have a negative effect for backward industries within a given economy.

The second chapter, "Do Electoral Rules Affect the Economic Performance of Manufacturing Industries?"[1] expands the comparative politics perspective of the first chapter to delve into the growth effect of electoral rules. We address whether alternative electoral rules have an impact on the economic performance of industries. The results suggest that majoritarian electoral rules are associated with a general negative effect on the economic performance of industries. However, this effect is contingent on the number of workers employed in the industry. Majoritarian electoral rules are associated with a growth-enhancing effect when industries are large. Complementary models using the Gallagher index as an alternative measure of electoral rules confirm that the less proportional the electoral rule, the lower the economic performance of average size industries tends to be.

The third chapter, "Electoral Systems and Income Inequality: a Tale of Political Equality" investigates the relationship between political institutions and within-country income inequality.

[1]This chapter is borne in upon my research collaboration with Timothy Yeung (Paris-Dauphine University).

Political economy literature has so far failed to offer a consensus on the effect that political institutions such as regime type (democracy *vs.* autocracy) and electoral systems (majoritarian *vs.* proportional representation) exert on within-country income inequality. Beyond the inequality effects of these *de jure* political institutions, this paper finds robust evidence that *de facto* distribution of political power crucially matters to income inequality. Based on a panel database of 121 countries for the period from 1960 to 2007, the results consistently associate even distributions of political power across socio-economic groups with lower levels of income inequality. The scale of this effect hinges upon the proportionality of electoral systems. However, regime type and electoral system are not consistently associated with a significant impact on income inequality.

Along the institutional spirit of the previous chapters, the fourth and last chapter[2], "Graduates' Opium? Cultural Values, Religiosity and Gender Segregation by Field of Study" studies the relationship between informal institutions (e.g. cultural values) and gender distribution across fields of study in higher education. I compute national, field and subfield-level gender segregation indices for a panel dataset of 26 OECD countries for 1998-2012. This panel dataset expands the focus of previous macro-level research by exploiting data on gender segregation in specific subfields of study. I consider two focal cultural traits: gender equality and religiosity, and control for potential segregation factors such as labour market and educational institutions, and aggregate-level gender disparities in math performance and beliefs among young people. The estimates fail to associate changes in the level of gender equality with gender segregation in higher education. Religiosity is significantly negatively associated with lower gender segregation in higher education. However, gender gaps in math beliefs seem to be stronger predictors of national-level gender segregation. Field and subfield-level analyses reveal that religiosity is associated with less gender-segregated fields of education, science, and health, and specifically with the subfield of social services.

[2]This chapter is intentionally placed as the *last* chapter to pay tribute to the landmark work of Claudia Goldin "A Grand Convergence: Its last chapter", *Am. Econ. Rev.* (2014).

Resumen

Esta tesis doctoral en Ciencias Económicas reúne cuatro capítulos que se enmarcan dentro de las ramas de la Economía Política y la Economía Institucional. La tesis investiga la relación entre las instituciones políticas, así como instituciones informales tales como los valores culturales, y aspectos de la economía y educación, como es el crecimiento industrial, la desigualdad por renta o la segregación de género en la educación terciaria.

Esta tesis tiene un carácter eminentemente empírico. No obstante, cada capítulo se basa en cierta medida en postulados teóricos formulados en una variedad de disciplinas de las Ciencias Económicas, como es la teoría de juegos o la teoría de la elección racional, así como en postulados de las Ciencias Políticas, como son los modelos teóricos de competencia electoral. En los cuatro capítulos que componen la tesis utilizo econometría de datos de panel como principal base metodológica. Las hipótesis que se estudian en cada uno de los capítulos son contrastadas usando bases de datos apropiadas para cada investigación. Por tanto, cada capítulo ha supuesto la elaboración de bases de datos con una alta cobertura de países y años. Las cuatro grandes preguntas que trato en esta tesis son las siguientes:

1. ¿La democracia tiene un efecto similar en el crecimiento de las industrias en un mismo país? ¿Es importante el cambio tecnológico en este efecto?
2. ¿Tienen las reglas electorales un impacto en el crecimiento de las industrias?
3. ¿Qué relación tienen las instituciones electorales y la igualdad política con la desigualdad por renta dentro de los países?
4. ¿Tienen los valores culturales una relación con la distribución de género en los campos de estudios terciarios?

El primer capítulo de la tesis se titula "The Growth Effect of Democracy and Technology: an Industry Disaggregated Approach". El efecto de la democracia en el crecimiento económico sigue siendo una incógnita dentro de la rama teórica de la literatura en Economía Política. De

la misma manera, la literatura empírica en este ámbito no ha llegado a un consenso sobre el efecto económico de la democracia. Los resultados existentes muestran tanto efectos negativos como positivos derivados de mayores niveles de democracia en el crecimiento económico.

El meta-análisis de más de 100 estudios sobre el efecto económico de los regímenes políticos de Doucouliagos y Ulubasoglu (2008) sugiere que el efecto de la democracia sobre la economía es nulo o positivo, pero en ningún caso negativo. Este meta-análisis identifica como futuras líneas de investigación los efectos indirectos de la democracia, así como la interacción con otras dimensiones tanto sociales como económicas, en el impacto económico de los regímenes políticos. Sin embargo, todos los textos revisados por Doucouliagos y Ulubasoglu (2008) estudian el impacto de la democracia en resultados agregados de la economía: el producto interior público (PIB) per cápita o la tasa de crecimiento del mismo.

Este primer capítulo se hace eco de las limitaciones de estudios anteriores y ofrece una manera alternativa de abordar la cuestión del efecto económico de los sistemas políticos que tiene dos características principales. En primer lugar, este estudio empírico investiga el efecto de la democracia usando datos desagregados de la economía. En concreto, analizo el efecto de cambios políticos en el crecimiento del output de 61 industrias manufactureras, en países desarrollados y en vías de desarrollo. Los resultados demuestran cómo los mismos cambios políticos tienen efectos diferentes en las diferentes actividades económicas, beneficiando el crecimiento de determinadas industrias, y perjudicando a otras. Por consiguiente, el uso de datos agregados puede ser una de las razones por las que la literatura empírica no ha llegado hasta la fecha a un resultado consensuado sobre el efecto económico de los regímenes políticos.

En segundo lugar, este capítulo retoma una de las conjeturas de la economía política: la democracia es condicional a un cierto nivel de desarrollo de las naciones para tener un efecto positivo en la economía. Esta conjetura es el punto de partida de Przeworski y Limongi (1993), uno de los trabajos de referencia en la literatura, así como en Barro (1996) y Acemoglu et al. (2014), entre muchos otros. A diferencia de trabajos que se enfocan en la interrelación entre democracia y desarrollo del capital humano o económico, mi conjetura es que la democracia depende del desarrollo tecnológico de las industrias para tener un efecto positivo en el crecimiento económico de estas. En otras palabras, mi hipótesis es que la democracia ejerce un efecto positivo en aquellas industrias avanzadas tecnológicamente.

La hipótesis de este capítulo se basa en las contribuciones de North (1991) y Robinson (2003) sobre la captura de las instituciones por industrias poco eficientes, así como en el argumento de Acemoglu (2008) sobre los beneficios y perjuicios de la democracia en la innovación y desarrollo tecnológico. Mi capítulo se inspira además en el estudio teórico y empírico de Aghion et al. (2009), en donde conjeturan que los cambios políticos hacia regímenes democráticos pueden ser únicamente beneficiosos para industrias capaces de adaptarse a mayores niveles de competitividad económica. El enfoque de este capítulo complementa a Aghion et al. (2009) al incluir un mayor nivel de desagregación de las industrias, una mayor cobertura temporal y geográfica, así como al contrastar una variedad de índices de democracia.

Este capítulo conlleva la elaboración de una extensa base de datos de panel con información de las estadísticas industriales de la United Nations Industrial Development Organization (UNIDO) para 61 industrias manufactureras que operan en 72 países durante 1990-2010. Otra parte fundamental de este capítulo es el estudio de las diferentes conceptualizaciones de la democracia que existen en la literatura. Ofrezco de esta manera una comparativa exhaustiva entre los índices más usados en la literatura, como son los indicadores Polity IV, Boix, Cheibub et al., así como el indicador de Vanhanen. Sin embargo, también analizo y empleo en mis estimaciones nuevas definiciones, y por consiguiente, nuevas técnicas de medición de la democracia, como es el índice de *polyarchy* elaborado por el Varieties of Democracy Institute (V-Dem) de la Universidad de Gotemburgo, y el indicador Support Vector Machines Democracy Index (SVMDI) elaborado en Gründler y Krieger (2016).

Para averiguar el poder explicativo del nivel de democracia en el crecimiento industrial, especifico varios modelos econométricos que estimo con las técnicas propias de datos de panel: efectos fijos y el método de los momentos generalizado (GMM en sus siglas en inglés), desarrollado por Arellano y Bond (1991). Los resultados que obtengo sugieren que cambios políticos hacia sistemas más democráticos favorecen el crecimiento de las industrias tecnológicamente desarrolladas pero perjudica a aquellas que no innovan en su proceso de producción. Este trabajo ha sido aceptado para su publicación en el *European Journal of Political Economy.*

El segundo capítulo de esta tesis doctoral, "Do Electoral Rules Affect the Economic Performance of Manufacturing Industries?", nace de mi colaboración con Timothy Yeung (University of Paris-Dauphine, PSL University). Este trabajo investiga cómo las instituciones electorales afectan al crecimiento de las industrias dependiendo del tamaño de las mismas. En los primeros meses de la tesis participé en la Summer School Interdisciplinary Voting organizada por COST en su división en Computational Social Choice y la Universidad de Caen-Normandie en Caen (Francia), donde el seminario de André Blais inspiró mi interés por las reglas electorales y su efecto en la economía. Las reglas electorales son la herramienta parlamentaria para trasladar votos a escaños. Tanto teórica como empíricamente, las reglas electorales se asocian a importantes efectos socio-económicos.

Este trabajo está inspirado por los postulados de Persson y Tabellini (1999, 2003, 2009) y Persson et al. (2003, 2007) en donde teóricamente sugieren que los sistemas de regla mayoritaria son más proclives a la captura política por parte de determinados sectores de la población. La literatura empírica, por su parte, sugiere que los sistemas electorales más proporcionales (regla de representación proporcional) tienden a implantar un tipo de políticas que benefician al conjunto de la población, y se asocian con mayores niveles de gasto público en servicios sociales, educación y salud pública.

Este capítulo supone una continuación lógica al capítulo anterior. Si bien en el primer artículo sugiere que el uso de datos desagregados por industria ayuda a tener un mejor entendimiento del efecto de la democracia sobre el crecimiento económico, este segundo capítulo estudia además los sistemas políticos democráticos desagregados por instituciones electorales, en concreto, la regla electoral. Desde un enfoque industrial, estudiamos en qué medida las instituciones electorales influyen en el crecimiento. Con ello, establecemos una metodología que permite indagar si el efecto de las instituciones electorales es homogéneo en la economía, o si por el contrario, este efecto está supeditado a determinadas características de las industrias.

En base a los modelos de competencia electoral de Persson y Tabellini y a la literatura de grupos de interés de Ciencias Políticas, este capítulo conjetura que países de regla mayoritaria son más proclives a favorecer a determinadas industrias. En concreto, nuestra conjetura sugiere que las reglas mayoritarias pueden estar asociadas a una mayor protección a industrias que emplean a una cantidad de empleados grande. En este sentido, no puede considerarse que este grupo social, e.g. los trabajadores de una industria manufacturera determinada, represente los intereses del conjunto del electorado, dado que según la base de datos utilizada, este grupo de personas supone de media un 0, 01% de la población total.

El resultado que se deriva de este capítulo apunta a que los sistemas mayoritarios favorecen a industrias grandes. La interpretación de este resultado está en línea con el postulado dentro de las Ciencias Políticas y la Economía Política sobre la correlación entre proporcionalidad de los parlamentos y la implantación de políticas enfocadas a un mayor segmento del electorado.

El tercer capítulo de esta tesis, "Electoral Systems and Income Inequality: a Tale of Political Equality", investiga el rol de instituciones políticas en la desigualdad por renta dentro de los países. Durante mis estancias internacionales en el Wilf Family Department of Politics, New York University (NYU), tuve el enorme placer de completar el curso de doctorado en Comparative Politics del Profesor Adam Przeworski. Una de las tareas para completar este curso conllevaba la escritura de un artículo de investigación en temas de política comparada. Aproveché esta oportunidad para desarrollar este tercer capítulo y tener el privilegio de contar con el seguimiento del Profesor Adam Przeworski en las primeras fases de esta investigación.

Este capítulo está motivado por la observación del incremento de los niveles de desigualdad por renta dentro de los países en sistemas democráticos en las últimas décadas. De la misma manera que la literatura en Economía Política no ha llegado a un consenso en cuanto al efecto final de la democracia en el crecimiento económico, tampoco hay una respuesta clara a la causalidad ni el signo de la relación entre democracia y desigualdad por renta dentro de los países. Partiendo de esta base, este capítulo estudia la relación entre instituciones políticas y la desigualdad por renta poniendo el foco en la igualdad política y en las instituciones electorales. Mi hipótesis es que la igualdad política, entendida como una distribución uniforme del poder político entre la población independientemente de su posición socio-económica, puede jugar un papel más determinante que las instituciones electorales, o la democracia en sí, en la desigualdad por renta dentro de los países.

La conjetura de este capítulo se inspira en el modelo teórico de Acemoglu y Robinson (2008). En su artículo, Acemoglu y Robinson proponen que la economía no solo depende de instituciones políticas *de jure*, como son las instituciones electorales o la democracia como tipo de régimen político, sino que también dependen de las instituciones políticas *de facto*, como puede ser la igualdad política. Su modelo teórico expone cómo cambios institucionales que modifican la distribución del poder *de jure* no tienen por qué conllevar un cambio en el equilibrio de las instituciones económicas , tales como es la desigualdad por renta dentro de los países. Cambios en instituciones políticas *de jure* pueden ser compensados por un re-equilibrio de las instituciones políticas *de facto*, mediante por ejemplo sobornos, la captura de partidos políticos o fuerzas paramilitares, lo que conlleva al mantenimiento de la desigualdad económica. En este sentido, uno de mis objetivos en este capítulo es el de testar empíricamente el postulado teórico de Acemoglu y Robinson (2008).

Para este capítulo construyo una base de datos con información para 121 países a lo largo de 1960-2007. Esta base de datos está compuesta, entre otras variables, por los coeficientes Gini de desigualdad por renta bruta y neta, extraídos de la Standardized World Income Inequality Database (SWIID). Una de las contribuciones principales de este capítulo es el uso de una medida de igualdad política, obtenida de la base de datos del V-Dem Institute, que evalúa en una escala continua de 0 a 4 el nivel de uniformidad de la distribución del poder político entre diferentes status socio-económicos de la población.

El modelo econométrico propuesto tiene como variable dependiente el logaritmo de los coeficientes Gini de la desigualdad por renta bruta. Uso como variables independientes los retardos de un año de una variable categórica que identifica la regla electoral, que toma el valor de 1 para países con regla de representación proporcional y cero en el resto de casos, la igualdad política, así como variables control establecidas en la literatura en desigualdad económica. En este capítulo especifico modelos de efectos fijos para estimar el efecto de la igualdad política e instituciones electorales en la desigualdad por renta. Adicionalmente, el capítulo recoge diferentes modelos alternativos y técnicas de estimación que fortalecen los principales resultados de la investigación.

Las estimaciones de este capítulo sugieren que la igualdad política puede ser un determinante esencial en la distribución de la renta. De hecho, los resultados asocian la igualdad política con un poder explicativo mayor sobre la desigualdad por renta que las instituciones políticas *de jure*. Además, este capítulo provee nuevas alternativas a la cuestión del efecto de la democracia en la desigualdad por renta dentro de los países. En este sentido, los resultados apuntan a que no es el *tipo* de régimen político lo que está detrás de la desigualdad económica, sino la experiencia democrática como potencial factor de ésta. Más allá de los resultados asociados a las instituciones políticas, este capítulo sugiere una relación de la forma U entre el desarrollo económico y la desigualdad por renta dentro de los países, tal y como se encuentra en la literatura reciente (Dreher y Gaston, 2008; Lessmann y Seidel, 2017).

Continuando con el interés por las instituciones y su efecto en la economía, el último capítulo de mi tesis, "Graduates' Opium? Cultural Values, Religiosity and Gender Segregation by Field of Study", se aleja del foco político-institucional de los capítulos anteriores para estudiar cómo los valores culturales pueden afectar a las decisiones económicas de hombres y mujeres. Este capítulo está altamente influenciado por los seminarios en Economía de Género de la New School for Social Research (NSSR) que atendí durante mi estancia en la NYU, así como por mis participaciones en las conferencias de la International Association for Feminist Economics (IAFFE) y en el Gender and Economics Working Group del Institute for New Economic Thinking (INET).

Tal y como sugiere la Profesora Raquel Fernández (NYU), la agenda de investigación de la Economía Neo-Institucional no ha prestado suficiente atención a entender las causas y consecuencias de las importantes transformaciones de la familia, como forma más básica organización, y del rol de la mujer en las sociedades contemporáneas. Este tipo de literatura ha motivado mi interés por otro tipo de instituciones, más allá de las instituciones políticas, como son los valores culturales y las normas sociales de género, y su efecto en un aspecto social muy concreto: la segregación de género en los campos de estudio de la educación terciaria.

El número de mujeres en la educación terciaria supera al de hombres en la mayoría de los países occidentales. Sin embargo, se observa de manera general una sobre-representación de las mujeres en campos relacionados con las humanidades y la salud, mientras que los hombres se concentran en campos técnicos y científicos (Barone, 2011). La evidencia empírica sugiere que una parte de la brecha salarial de género en el mercado laboral viene explicada por la segregación de género en educación (Blau and Kahn, 2000; Bobbitt-Zeher, 2007). De hecho, la segregación de género en la educación terciaria supone una preocupación esencial dentro de las Ciencias Económicas, así como de otras disciplinas sociales como la Psicología Social o la Sociología. El fenómeno de la segregación de género en campos de estudio de la educación se conoce en la literatura como segregación horizontal de género, la cual se diferencia de la segregación vertical de género en tanto y cuanto no contempla el nivel de estudios dentro de la propia educación terciaria, por ejemplo entre grado, master o doctorado.

La literatura identifica los valores de igualdad de género (Fortin, 2005) así como la religión (Guiso et al, 2003; Algan y Cahuc, 2006) como potenciales factores de la disparidad de género en decisiones y resultados económicos, como puede ser la elección del campo de estudio de la educación terciaria. En base a estos trabajos, este capítulo se cuestiona si los valores culturales guardan una relación estadísticamente significativa con los niveles de segregación en los campos de la educación terciaria, y en ese caso, qué signo tiene esta relación.

Mi objetivo con este capítulo es doble. Primero, intento ofrecer un análisis descriptivo de las tendencias de segregación horizontal de género de la educación terciaria en países occidentales. Para ello, he construido una base de datos de panel con información para 9 campos y 23 subcampos de estudio en 26 países de la Organización para la Cooperación y el Desarrollo Económicos (OCDE) durante el periodo 1998-2012. En segundo lugar, mi objetivo es entender un poco más los factores que hay detrás de este fenómeno. En concreto, centro mi interés en estudiar el papel en la segregación horizontal de dos tipos de valores culturales medidos a nivel nacional: la igualdad de género y el nivel de religiosidad.

Este estudio propone el uso de dos indicadores de segregación: el índice de disimilitud (Duncan y Duncan, 1955), que ha sido usado previamente en estudios en Ciencias Económicas, y el índice de asociación (Charles y Grusky, 1995), que ha sido utilizado eminentemente en estudios de Sociología. El primer índice arroja el porcentaje de mujeres que debería cambiar de campo de estudio para re-equilibrar la distribución de género en la educación terciaria. Sin embargo, el índice de disimilitud no identifica qué campos están sobre-representados por hombres o mujeres. Es por ello que uso un segundo índice, el llamado índice de asociación, el cuál mide el grado en el que cada campo o subcampo de estudio está sobre-representado por hombres o mujeres.

Los datos que ofrece el capítulo evidencian de manera descriptiva el diferente grado de segregación de género que existe en países occidentales. A nivel de segregación nacional, Turquía y Polonia son los países menos segregados, mientras que Finlandia y Alemania obtienen los mayores niveles de segregación. El análisis a nivel de campos y subcampos de estudio de la educación terciaria muestra un cierto grado heterogeneidad dentro de los países de la muestra. Se identifican ciertos patrones, como son la sobre-representación de las mujeres en estudios relacionados con la salud en los países nórdicos, y la sobre-representación de las mujeres en campos relacionados con la educación en países mediterráneos.

Este capítulo especifica modelos econométricos de efectos fijos para estimar el papel de los valores culturales en la segregación horizontal de género en la educación terciaria. Para medir los valores culturales de cada país, la base de datos incluye los índices de igualdad y desigualdad de género, como son el Gender Inequality Index del United Nations Development Programme (UNDP) y el Gender Equality Index del International Institute for Democracy and Electoral Assistance (IDEA). Para medir el nivel de religiosidad, utilizo la base de datos World Value Survey (WVS) para extraer el porcentaje de personas que consideran que Dios es muy importante en sus vidas.

Para aislar la relación entre valores culturales y segregación horizontal de género de otros factores que pueden influir dicho fenónemo, los modelos econométricos controlan por otras variables que miden, por ejemplo, el tipo de estructura económica, el mercado laboral o los sistemas educativos en cada país de la muestra. La literatura reciente en este ámbito sugiere que la auto-percepción de la juventud sobre sus habilidades en las matemáticas puede ser un determinante crucial en la elección del campo de estudio de la educación terciaria (Ceci et al., 2014; Eccles y Wang, 2016). De esta manera, los modelos también incluyen las brechas de género en la ansiedad, auto-concepto y auto-eficacia en las matemáticas de estudiantes de secundaria, extraídos de las olas de 2003 y 2012 del Programme for International Student Assessment (PISA) para los países de la muestra.

Los resultados de este capítulo tienden a sugerir que los valores culturales pueden guardar una relación con la segregación horizontal de género, en concreto, la religión. Mientras que las estimaciones no relacionan los índices de igualdad o desigualdad de género con la segregación, la mayoría de los modelos propuestos identifican una correlación estadísticamente significativa entre el nivel de religiosidad del país con la segregación horizontal de género. Esta relación es negativa, lo que sugiere que a mayor nivel de religiosidad del país, la segregación horizontal de género en la educación terciaria es menor. Este resultado es similar a otros estudios recientes, como es el artículo de Falk y Hermle (2018), en donde asocian mayores niveles de desarrollo económico e igualdad de género con mayores discrepancias en las preferencias entre hombres y mujeres.

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"Remember that all models are wrong; the practical question is how wrong do they have to be to not be useful".

George Box and Norman Draper, 1987, pg. 74

1.1 Introduction

The theoretical and empirical sides of democracy-growth literature fail to offer a consensus on whether democracy enhances or diminishes growth. The vast majority of studies to date focus on the effect of democracy on the whole economy. Those studies generally employ nationwide economic indicators such as the level or growth rate of GDP per capita as their dependent variable[1]. This paper however considers that the growth effect of democracy might differ from one sector to another within economies. It focuses on how rising levels of democracy impact on the economic performance of manufacturing industries, and employs disaggregated growth rates as a dependent variable. This disaggregated manufacturing approach reveals that democracy affects industries differently within the same economies. These results suggest that this effect is contingent on the technological development of industries.

In the words of Przeworski (2016), the functions and limits of democracy are a never-ending quest which has sparked a flourishing scholarship on the growth effects of democracy[2]. This literature features three main opposing arguments that have fired up the research agenda on

[1] See Doucouliagos and Ulubaşoğlu (2008) for a meta-analysis of democracy-growth literature.

[2] See *inter alia* Przeworski and Limongi (1993), Alesina and Perotti (1994) and Sirowy and Inkeles (1990), De Haan and Siermann (1996), Baum and Lake (2003) for an understanding of the early background of the large body of democracy-growth literature.

this topic. The *conflict view* suggests a negative effect of democracy on growth. Huntington (1968) argues that democracies lend themselves to inefficient popular demands whereas autocratic regimes are better able to implement unpopular, profitable investments needed for growth. The experiences of the Tiger economies - South Korea, Taiwan, Hong Kong and Singapore - which introduced democracy after economic reforms and that of the Chinese economy reinforce the conflict view of the growth effect of democratic regimes (Huntington et al. (1976), Guo (2007), Xu (2011), Bell (2016)). In sharp contrast, the *compatibility school* states that democracy promotes economic growth (Gerring et al. (2005), Acemoglu et al. (2014b), Madsen et al. (2015)) and encourages more stable, higher quality development (Rodrik (2000), Bhagwati (1995)). Rodrik and Wacziarg (2005), and Papaioannou and Siourounis (2008) find that democratisation tends to produce higher rates of economic growth in the future. This view notes that democracy enforces growth-enhancing features precisely through the provision of political rights and civil liberties (North (1990)). A third, sceptical view finds that democracies make little or no difference, and consequently calls into question the causal effect of democracy on growth (Bardhan (1993), Bhagwati (1995), Przeworski (2000), Mulligan et al. (2004), **?** and Murtin and Wacziarg (2014)).

These opposing approaches to the growth effect of democracy may result from the complexity of conceptualising political regimes (Fukuyama (2007)). Different conceptualisations, and thus alternative measurements of democracy, are an issue that is exacerbated by differing modelling and research designs (Sirowy and Inkeles (1990)). The meta-analysis of 84 studies of the effect of democracy on GDP growth performed by Doucouliagos and Ulubaşoğlu (2008) shows the wide variety of methodologies used, and finds that the overall effect of democracy does not seem to be detrimental to growth. Indeed, a large body of research suggests that the indirect effect of democracy through socio-economic, political and demographic features is conducive to growth. Political economic literature accounts for growth-promoting mechanisms of democracy through the accumulation of physical or human capital (Helliwell (1994), Baum and Lake (2003), Dawson (1998)), political stability conjecture (Alesina et al. (1996); Rodrik (1998)) and economic freedom (Sturm and De Haan (2001)). However, growth-diminishing channels through democratic trade-offs between property rights, entry barriers and redistribution taxes have been also suggested (Plümper and Martin (2003), Rodrik and Wacziarg (2005), Acemoglu et al. (2008)).

The main questions that this paper seeks to answer are whether democracy exerts a different effect on different industries within the same economy, and if so whether those effects are contingent on technological development. I combine the industry approaches employed in Rajan and Zingales (1998) and Aghion et al. (2009)) with the old suspicion that democracy exerts a positive effect on economic performance contingent upon other factors (Lipset's hypothesis (1959), Przeworski and Limongi (1993), Acemoglu et al. (2014b). Building on the linkages between democracy, economic freedom and regulation (De Haan and Sturm (2000), (2003), Lundström (2005), Djankov et al. (2002), Rode and Gwartney (2012)), I explore whether the interplays between democracy and technological development might determine the sign and magnitude of the effect of democracy on growth. I surmise a mechanism that works through the promotion of democracy of lower market-entry barriers and higher levels of economic freedom. This influence favours the economic performance of advanced industries, which might be better able to adapt and thrive in more competitive economic scenarios than backward industries. Consequently, technologically advanced industries might benefit from more democratic political institutions whereas backward industries become worse off in more democratic environments.

I employ an informationally demanding database with data on 61 International Standard Industrial Classification (ISIC) industries operating in 72 countries from 1990 to 2010. I use a novel, sensitive measure of democracy (Gründler and Krieger (2016)) and control for a wide variety of empirically informed drivers of economic performance in manufacturing. My results show that the growth-effect of democracy varies from one industry to another within an economy. These results further reveal that the growth-effect of democracy is contingent on the technology with which industries operate. Advanced industries benefit from political regime changes towards more democratic institutions. By contrast, the same political changes harm the economic performance of backward industries. These results are robust to alternative conceptualisations of democracy, which also serve as a review of the state-of-the-art indices of democracy. The final effect of democracy is scrutinised for different levels of technological development and it turns out that greater democracy has no effect on highly backward industries.

The paper is organised as follows. Section 2 discusses theoretical reasons and empirical findings to date on the interaction between democracy and technology and its aftermath for growth. Section 3 explains the data and specifies a panel data model for analysing that interaction. Section 4 presents the main results. Section 5 tests the sensitivity of those results to alternative specifications and estimation techniques. Section 6 concludes and offers new lines of research.

1.2 The interplay between democracy and technology

The main hypothesis of this paper is that democracy might exert different growth effects across industries operating within the same economy. Further, the paper surmises that the differential growth effect of democracy hinges upon the technological development of industries. I build on Acemoglu et al. (2006) and Caselli et al. (2006) to define technological development in terms of distance from the World Technology Frontier (henceforth called the WTF), so that industries close to the WTF are seen as technologically advanced and those further away as backward. Acemoglu et al. (2006) suggest that the organisation of firms and production is different in industries closer to the WTF. Industries closer to the WTF are more prone to switch to an innovation-based strategy as a source of productivity growth. By contrast, industries further from the WTF are more likely to adopt an investment-based strategy. Thus, these alternative strategies of advanced and backward industries might involve government interventions having alternative productivity effects across industries in the same economy.

Aghion et al. (2009) come close to surmising that the effect of democracy on growth hinges upon technology. They show theoretically and empirically that democracy promotes innovation in advanced industries but not in backward ones. Thus, one might expect democracy to have a stronger impact on productivity growth in sectors that are closer to the WTF. Freedom of entry is also determinant for sectors close to the WTF since, as suggested in Aghion et al. (2008), entry of new firms and competition spur innovation at high levels of technological development but discourage innovation in backward sectors. A plausible nexus between technology and democracy on economic growth is broadly supported by three strands of political economic scholarship on democracy regarding regulation, economic freedom and innovation.

1.2.1 Democracy and regulation

Democracy shapes the intervention of the state in the economy and crucially determines the level and quality of regulation[3]. The seminal empirical works on democracy and regulation by Djankov et al. (2002, 2006) and Jalilian et al. (2007) show that more democratic and limited governments have lighter regulation and thus lower market-entry barriers. Regulation might also be subject to rent-seeking attitudes on the part of politicians and bureaucrats (Shleifer and Vishny (2002)). Along those lines, Perotti and Volpin (2007) provide cross-sectional evidence

[3]For reviews of the canonical theories on the regulatory role of the state see the following in regard to public interest (Pigou (2013)) and the public choice view of regulation (Tullock (1967); Stigler (1971); Peltzman (1976)).

for the association of political accountability with investor protection and lower entry costs. Weyland (2002) surmises theoretically that democracy weakens the political power of interest groups to favour protectionism and rent-seeking, so transitions to democracy are conducive to more economic freedom. Ultimately, democratisation can provide higher levels of political accountability that reduce protection of vested interests, so that the resulting lower market-entry barriers work in turn in favour of those sectors that are better able to adapt to such new economic scenarios.

1.2.2 Democracy and economic freedom

The literature on political economy offers sound empirical evidence of a direct channel by which democracy is conducive to economic freedom (Pitlik and Wirth (2003) and Pitlik (2008)). De Haan and Sturm (2003) use both cross-section and panel data techniques along with different measures of democracy to show that the increase in economic freedom between 1975 and 1990 in developing countries was driven to certain extent by the level of political freedom. These findings are further supported by Rode and Gwartney (2012) using a panel data set covering 48 political transitions from authoritarianism to democracy since the mid-1970s. A straightforward association of better regulation and economic freedom with a pro-growth effect is also found in the literature. An overall direct positive association of economic freedom with economic growth is suggested by Doucouliagos and Ulubasoglu (2006). This evidence supports the idea of a channel through which democracy fosters economic growth through its effect on economic freedom and regulation.

1.2.3 Democracy and the adoption of new technologies

The hypothesis that democracy might be more beneficial for technologically advanced industries is ultimately built on political economic theory concerning the adoption of new technologies in democratic environments. The potential of new technologies is difficult to evaluate ex-ante, so investments in such technologies are based on hunches about the future (Boschini (2006), Hodgson (2015)). Interest groups that believe that they will lose out from the adoption of new technologies will use their political power to block the development of such technologies. Democracy is less likely to provide special interest groups with such political tools. Additionally, democracy is associated with more stable political regimes (Alesina and Perotti (1996), Rodrik (2000)). Political stability and the securing of property rights make democracies more appropriate environments for technological innovation than oligarchies, as also stated in Acemoglu (2008). Milner (2006) provides panel data evidence on the crucial role of regime type in the spread of the Internet, as an example of a new technology. Her investigation underscores that autocratic institutions tend to hamper technological change and suggests that the rate of adoption of technology affects economic development. Gao et al. (2017) further explore the link using panel data estimates, and conclude that democracy is positively but indirectly associated with innovation.

I apply these postulates to a disaggregated industry context. Industries with a comparative advantage in new technologies are more likely to grow in democratic countries, since democracies are precisely the types of regime associated with higher levels of economic freedom and lower limits on market entry. By contrast, new investment opportunities are reduced when market-entry barriers are high and property rights are not properly enforced. Autocratic regimes may be more likely to keep political power in the hands of producers which have ex-ante comparative advantages in political terms and block the development of industries using new technologies. The empirical evidence on the link between democracy and economic freedom implies that higher levels of democracy will harm industries far from the WTF. Backward industries operating in relatively undemocratic countries might enjoy some degree of political favouritism -through the capture of political elites or rent-seeking political attitudes-, or high entry barriers that reduce competition from new or politically weaker industries. However, as political regimes become more democratic market-entry barriers are reduced, allowing for more innovative and more competitive economic scenarios. Greater economic competition might expel backward industries from the market and replace them by technologically more advanced industries. Hence, higher levels of democracy might have differential effects on industries depending on how far they are from the WTF.

Finally, a case in point of how political regimes may affect the entry of new firms and the adoption of technology is the Porfirio Díaz dictatorship in Mexico from 1876 to 1911. As cited in Acemoglu (2008):

"Manufacturers who were part of the political coalition that supported the dictator Porfirio Díaz were granted protection, everyone else was out in the cold." (p. 18 in Haber et al. (2003)). The regulatory practices employed in early 20th century Mexico were restrictions on imports and regulatory policies without legislative approval, custody of banking services and administering of federal taxes to government creditors (Maurer and Gomberg (2004), Haber et al. (2003)). The regime was able to specify and enforce property rights, which were private rather than public goods. Linking the case of the Porfirio Díaz regime to current debate is not far-

fetched, as Robinson (2003) finds similarities between the contemporary Russian economy and that of Mexico in 1900[4].

1.3 Data and specification

The hypothesis tested in this paper is that democracy exerts different effects on the economic performance of industries depending on their technological development. I surmise that democracy has a growth-enhancing effect on developed industries (close to the WTF) because they are better able to adapt to more competitive and innovative markets. Most political economic literature suggests that economic freedom and higher standards of regulatory policies are to some extent caused by political liberalisation brought about by democratisation processes. Thus, industries that operate close to the WTF will, as argued by Aghion et al. (2009) and Acemoglu (2008), benefit from increasing levels of democracy, while those far from the WTF will be displaced from the market insofar as they are less likely to adapt to new, more competitive and economically freer markets. This hypothesis is analysed using an unbalanced panel dataset covering 61 International Standard Industrial Classification (ISIC) manufacturing industries from 72 countries for the period from 1990 to 2010, as listed in the Appendix A (Tables A1.1 and A1.2)[5]. The unit of observation is country-industries, which range in number from 2,423 to 3,267 depending on the controls included in the models. To estimate whether democracy exerts different effects on manufacturing industries depending on technology, the following panel data model is specified:

$$\begin{aligned}\triangle log(Y_{ict}) = \beta_0 + \beta_1 Distance_{ict} + \beta_2 Democracy_{ct} + \beta_3 Distance_{ict} * Democracy_{ct} \\ + X'_{ict}\alpha + Z'_{ct}\omega + u_{ict}\end{aligned} \tag{1.1}$$

$$\triangle log(Y_{ict}) = \log y_{ict+1} - \log y_{ict}$$

$$u_{ict} = \gamma_{ic} + \lambda_{ct} + \delta_{it} + \varepsilon_{ict}$$

$$i = industry; c = country; t = year$$

[4]Mexico in 1911 scored 0 in the Polity2 index. Some of the countries in the sample employed in my research (Azerbaijan, China, Egypt, Iran, Morocco and Tanzania) score lower on democratic values than early 20th-century Mexico.

[5]Specific information per country can be found in the Appendix B.

where Y_{ict} is the output of industry i in country c in year t such that the dependent variable is the growth rate of the output of manufacturing industries in year $t+1$. In this way, all the explanatory variables correspond to period t so as to reduce possible reverse causality issues. $Distance_{ict}$ is the measure of technological development, which is industry and country-specific. $Democracy_{ct}$ denotes the political regime of the country in which industries are located, and $Distance_{ict} * Democracy_{ct}$ is the interaction of distance and democracy. A statistically significant coefficient - either positive or negative - associated with this interaction (β_3) would give leverage to the argument that the growth effect of democracy hinges on technological development. X_{ict} includes a set of control variables at a country-industry level, whereas Z_{ct} includes country-level controls (see below for more information). The term γ_{ic} captures time-invariant effects that may arise because of both countries' idiosyncrasies and industrial peculiarities, whereas δ_{it} and λ_{ct} show country-year and industry-year fixed effects respectively, which can also be an unobserved source of heterogeneity. Finally, ε_{ict} denotes the error term[6].

1.3.1 Dependent variable

The dependent variable is the annual growth rate computed by log-differencing the output of 61 manufacturing industries disaggregated according to the International Statistical Industrial Classification (ISIC). Disaggregated data on manufacturing industries are collected from the United Nations Industrial Development Organisation (UNIDO) Industrial Statistics Database at the 3-digit level of ISIC (INDSTAT4) and transformed into real terms (constant 2010 US dollars). Previous studies using disaggregated manufacturing data offer comprehensive arguments in favour of this approach and the use of the UNIDO Industrial Statistics Database (Rajan and Zingales (1998), Imbs and Wacziarg (2003), Aghion et al. (2009), Vaz and Baer (2014).

[6]It should be noted that a general-to-specific examination of the fixed effects specified in Equation (1.1) revealed that only γ_{ic} and δ_t fixed effects need to be included. This examination follows the insights in Balazsi et al. (2018) for multidimensional fixed effects panel data models.

1.3.2 Explanatory variables

Distance from the World Technology Frontier

I use the concept of distance from the WTF to measure the technological development of industries. The variable is defined as:

$$Distance_{ict} = 1 - \frac{\log(VA_{ict}/EMP_{ict})}{\log(max_{c'}(VA_{ic't}/EMP_{ic't}))}$$

$$i = industry; c = country; t = year$$

Where VA_{ict} and EMP_{ict} stand respectively for value added and the number of employees, and $max_{c'}(VA_{ic't}/EMP_{ic't})$ refers to the world maximum VA/EMP ratio of industry i. The data on both the number of employees per industry and value added are collected from the UNIDO database, and the latter is transformed into real terms (constant 2010 US dollars). Distance from the world technology frontier (WTF) is a yearly assessment of how far each industry is from the industry that marks the technology frontier, i.e. the country that operates with the highest ratio of value added per worker per industry. Note that each industry is compared with its counterparts in the rest of the world and not with the ratio of value added per worker in other industries within a country or from one country to another. The variable ranges from zero (meaning that the industry operates with the most advanced technology) to one (meaning that the industry operates with the lowest ratio of value added per worker). The sample average distance in the database constructed in this paper (0.16) is the same as that of the sample used in Aghion et al. (2009), although they employ a less disaggregated approach. The industries with the highest average levels of technological development (i.e. those which are on average closest to the WTF) are the processing of nuclear fuel, electricity distribution and control apparatus, insulated wire and cable and aircraft and spacecraft. At the other end of the technological spectrum are tobacco products, coke oven products, basic chemicals and motor vehicles. The countries closest on average to the WTF are the USA, Japan and New Zealand, while those furthest away are Madagascar, Vietnam and Georgia[7].

Democracy: Conceptualisation and measurement

The Support Vector Machines Democracy Index (SVMDI) provided in Gründler and Krieger (2016) is selected as the measure of democracy across countries. The validity of the results

[7] The Appendix B provides histograms of the distance from the WTF of each industry.

is checked by also employing five alternative measures of democracy. There are three major ongoing debates in the political economy literature concerning the measuring of democracy. The first issue is that it remains unclear what components should be included in a democracy index (Boix et al. (2013)); the second issue is what aggregation methodology should be used to combine the components into a single measure; the third is the proliferation of different numerical forms of the various measures. These debates have produced two broad types of definition of democracy, known as "minimal" and "extensive" definitions. These indices seek to measure the same phenomenon (i.e. democracy), but they are conceptually different and employ different units of measurement and methodologies to aggregate different political attributes of regimes. Different definitions mean different combinations of regime components of democracy and different forms of aggregation, so the data vary in terms of countries and periods of coverage from one index to another[8].

The dichotomous categorisations of democracy in Boix et al. (2013) and Cheibub et al. (2010) apply a minimal conceptualisation of democracy focused on alternative components of political regimes. The Boix[9] index focuses on two main attributes: contestation and participation. The Cheibub[10] index (Cheibub et al. (2010)) extends the democracy-dictatorship index constructed by Alvarez et al. (1996) and is based on office and contestation as determinants of political attributes of democracies. In both cases, 0 means no democracy and 1 means democracy. Vanhanen and Lundell (2014) also offer a minimal conceptualisation of democracy, although it is a polychotomous variable defined as the outcome of multiplying two electoral attributes regarding competition and participation[11]. However, scholars have pointed to the lack of theoretical justification of the two attributes as the main limitation of the Vanhanen index (Munck and Verkuilen (2002), Gründler and Krieger (2016)). The Vanhanen index ranges from 0 to 45.6 in my dataset.

The minimal conceptualisations of the Boix, Cheibub and Vanhanen indices are in sharp con-

[8]A classification of the types of measures of democracy considered in my analysis and cross-correlations are provided in the Appendix C.

[9]The Boix index considers a political regime as democratic if 1) the executive is directly or indirectly elected in popular elections and is responsible either directly to voters or to a legislature; 2) the legislature (or the executive if elected directly) is chosen in free and fair elections; and 3) a majority of adult men have the right to vote.

[10]In order for a country to be a democracy as envisaged by Cheibub 1) the chief executive must be chosen by popular election or by a body that was itself popularly elected; 2) the legislature must be popularly elected; 3) there must be more than one party competing in the elections; 4) an alternation in power under electoral rules identical to the ones that brought the incumbent to office must have taken place.

[11]The Vanhanen index results from multiplying "participation" (the percentage of the total population who actually voted in the election) by "competition" (the percentage of votes gained by the smaller parties in parliamentary and/or presidential elections) and dividing by 100.

trast to the well-known Polity2[12] index from the Polity IV Project (Marshall et al. (2014)). Polity2 is a polychotomous, categorical variable ranging from -10 to 10 which modifies the combined annual Polity score by applying a special treatment to fix instances of political interregnum, transition or interruption. This is an extensive conceptualisation of democracy that differs from those above in terms of the underlying definition of democracy, the nature of the data and the type of measurement and aggregation. Although widely used, the Polity 2 index is surrounded by a great deal of controversy, as some scholars cast doubts on the precision of the Polity IV measures (Treier and Jackman (2008)). Finally, the Polyarchy measure of Teorell et al. (2016), based on Varieties of Democracy (V-Dem) data, focuses on five categories: elected officials, free and fair elections, freedom of expression, associational autonomy and inclusive citizenship. This index is inspired by the work of Schumpeter (2013) and Downs (1957). More specifically, as these authors argue, the index anchors core "institutional guarantees" in the concept of "polyarchy" defined in Dahl et al. (2003) and Dahl (2008). Consequently, the conceptualisation of the V-Dem data views elections -and the institutions that uphold the democratic qualities of elections- as the core of the concept of democracy.

Due to the criticism levelled at the measures above, I employ the SVMDI indicator of democracy, which strives to include novel techniques for computing and scoring political regime features. Gründler and Krieger (2016) translate the issue of the aggregation of political attributes into an optimisation problem by using Support Vector Machines and machine learning algorithms. Calculating the SVMDI index involves an unambiguous characterisation of highly democratic and highly autocratic political regimes. Based on that characterisation, the authors employ Support Vector regressions (a mathematical algorithm for pattern recognition), along with eleven observable political variables to provide a continuous scale of democracy in the [0,1] interval[13]. My reasons for choosing the SVMDI as the main democracy indicator in the analysis below are threefold. First, the SVDMI is particularly convenient in the context of democracy-growth due to its sensitivity to political developments. Indeed, SVMDI shows trends in the evolution of democracy that remain unreported in other discrete measures of democracy such as the Polity2 index[14]. Second, the use of machine learning for measuring democracy enables researchers to achieve highly accurate classifications (Gründler and Krieger

[12]Due the similarities and high correlation between the Polity2 index and the also well-known Freedom House (FH) index I only include the former. However, the same results are reached using the FH political rights and civil liberties indices. Those results are available from the author.

[13]All together the eleven variables account for four broader aspects: political participation, independence of the judiciary, civil liberties and freedom of the press.

[14]Figure C1.1 in the Appendix C provides a comparison of the differential trends of SVMDI in countries that score 10 in the Polity2 index.

(2016)). Thirdly, if SVMDI is used the analysis benefits from the broader coverage of this index in terms of countries and time.

Country-industry level controls

X_{ict} includes three covariates at country-industry level that control for potential industrial growth drivers such as labour and employment. In this sense my analysis supplements that of Aghion et al. (2009) by considering potential effects at country-industry levels. Drawing on the literature on special interest politics (Grossman and Helpman (2001)), I control for potential lobbying ability and unequal political power that might be conducive to favourable policies, and thus to better economic performance. The variable *Output share*, defined as the weight of each of the 61 ISIC industries in total manufacturing output, is included to capture how economically influential and financially powerful each industry is relative to other industries. Additionally, the effectiveness of lobbying and the electoral power of industries (and thus the consequent effects on growth) might be driven by the number of workers (voters) that an industry employs (McGillivray (2004)). To capture these potential effects, I include the variables *Employment* and *Establishments*, defined respectively as the ratio of the number of employees and the number of establishments in each industry, to the total population.

Country-level controls

In the literature on the effects of democracy on nationwide economic growth there has been an increase in neoclassical growth models that account for indirect or interactive effects through human capital, trade openness and economic freedom, among other channels. The variable Z_{ct} in Equation (1.1) accounts for socio-economic, political and demographic factors, which are essential to isolate the effect of democracy and its interaction with technology on manufacturing industries (see Doucouliagos and Ulubaşoğlu (2008)). Nationwide economic development might have an effect on the economic performance of manufacturing industries. This potential effect is controlled for by including the growth rate of gross domestic product per capita (*GDP pc growth rate*) as in Aghion et al. (2009). I include trade as a percentage of GDP (*Openness*) to control for potential effects on economic performance of industries (Frankel and Romer (1999), Dawson (1998)) and on the workings of political regimes (Garrett (2000), Dutt and Mitra (2002), Milner and Kubota (2005), Milner and Mukherjee (2009)). The US dollar to local currency exchange rate (*Real exchange rate*) is included to rule out any possible effect of exchange rate movements on the main results. I also control for major demographic factors such as population and human capital, which might play a role in the economic performance of manufacturing industries (Lucas (1988a), Baum and Lake (2003), **?**, Benhabib et al. (2013), Alesina et al. (1996), Lipset (1963)). By so doing, I also control for potential interplays between these factors and the workings of democracies (Rokkan (1970b), Blais and Massicotte (1997)). Not only are human capital externalities crucial in regard to the adoption of new technologies but levels of human capital could also be an important determinant of the monitoring power of citizens over their legislators, leading to more benign politics, less violence and greater political stability. *Population* is the natural logarithm of the total population and *Human Capital* is the average number years of educational attainment of the population over 15 year-old.

As pointed out in Section 2, regulation is crucial to understanding how the growth effect of democracy interplays with technology. As suggested by North (1990), low market-entry barriers and appropriate economic institutions regarding property rights and secure contracts go hand in hand with political rights. My hypothesis relates to economic freedom insofar as regulatory areas are embedded in the concept of economic freedom. Indeed, features that were formerly attributed to political freedom are nowadays defined as economic freedom[15] (Gwartney and Lawson (2003), Doucouliagos and Ulubaşoğlu (2008)). Previous attempts to analyse the hypothesis of a technology-contingent effect of democracy on manufacturing growth were based on cross-sectional data and relied on the number of procedures for market entry as a regulatory measure (Djankov et al. (2002), Aghion et al. (2009)). I depart from that literature by using the *Regulation* component from the economic freedom index by the Fraser Institute (Gwartney et al. (2016)) in a panel data context[16].

The Fraser Institute provides a proxy of regulation that awards scores out of ten, where higher values indicate a freer, more business-friendly environment. This measure is used extensively by economic researchers[17] and outperforms other alternative measures in two main ways. First, the Fraser Institute index of regulation benefits from a multifaceted concept of regulation by considering the regulatory standards of the credit market, labour market and business environment. This is an advantage with respect to other indicators which focus on just one facet (e.g. the number of procedures for market entry employed in Djankov et al. (2002) and Aghion et al. (2009)). Second, other regulation measures used as components of economic

[15]As defined by Gwartney and Lawson (2003) and published in the annual report Economic Freedom of the World (EFW), economic freedom "expresses a variety of policies consistent with i) smaller governments; ii) secure property rights; iii) access to sound money; iv) freedom of exchange; and v) freer credit and labour markets".

[16]In models available on request I employ alternative regulation measures, such as the number of procedures for market entry (World Bank Doing Business) by Djankov et al. (2004) and the World Bank Governance Indicators (WBGI) on the quality of regulation by Kaufmann et al. (2011).

[17]See Berggren (2003), De Haan et al. (2006), Rode and Gwartney (2012)) for reviews and applications.

freedom indices (such as the Heritage Foundation/Wall Street Journal) use rankings rather than scores of business regulation, and would thus be inaccurate in unbalanced panel data regression settings.

Finally, the number of consecutive years of the current regime type (*Age of democracy*), as provided by Boix et al. (2013), is also controlled for. As shown by Persson and Tabellini (2009), the age of democracy is crucial to the dynamics of economic and political regime changes. At the same time, duration of democracy is also positively associated with economic freedom (De Haan and Sturm (2003)), which might set an additional, indirect mechanism that promotes growth in advanced technologies. Table 1.1 shows the descriptive statistics for the variables included in the empirical analysis and Table A1.3 in Appendix A provides information on the data sources.

Table 1.1: Summary Statistics

Variable	**Mean**	**Std. Dev.**	**Min.**	**Max.**	**N**
Industry growth	0.247	0.489	-4.085	6.608	14,037
Distance from the World Technology Frontier	0.163	0.11	0	0.77	14,037
SVMDI	0.792	0.29	0.019	0.979	14,037
Boix	0.866	0.341	0	1	12,428
Cheibub	0.864	0.343	0	1	14,037
Polity2	7.767	4.419	-7	10	14,037
Vanhanen	26.389	10.852	0	45.6	14,037
Polyarchy	0.761	0.217	0.111	0.948	14,037
Output share	0.02	0.032	0.000	0.78	14,037
Employment	0.001	0.002	0.000	0.063	14,037
Establishments	0.000	0.000	0.000	0.003	14,037
GDP *per capita* growth rate	0.037	0.034	-0.11	0.249	14,037
Openness	76.871	37.303	16.75	210.374	14,037
Real exchange rate	0.570	0.525	0.000	1.809	14,037
Regulation (Area 5 EFW)	6.786	1.036	2.851	8.941	14,037
Population (*ln*)	16.661	1.555	13.757	20.994	14,037
Human capital	9.359	2.223	2.45	13.146	14,037
Age of democracy	52.772	45.303	1	207	14,037
Industry output (in levels *ln*)	19.341	2.616	6.45	26.014	14,037

Based on the sample used in the estimation in Table 2 Column 4

1.4 Main results

Table 1.2 presents within-group estimates of a sequence of alternative specifications. The within-group estimator yields consistent estimations by getting rid of the individual and time fixed effects by demeaning the Equation in (1.1). The Hausman tests conducted for models in 1.2 clearly indicate the accuracy of fixed effects rather than random-effects panel data estimation in all the following models. I calculate the clustered-robust variance matrix estimator at country-industry level (White (1980), Newey and West (1987)), which is consistent in the presence of any kind of heteroscedasticity or serial correlation, in all the subsequent models. Strong exogeneity of regressors is assumed, and correlation is allowed to take any form within-group but not from one group to another.

First, I present the estimates including only distance and democracy, with no interaction or control variables. Next, interaction is included in Column 2 (1.2) and, as expected, it is statistically significant and negative. These results should be interpreted with extreme caution due to the possible omission of relevant variables caused by the lack of controls. However, similar results are obtained by adding the control sets at country-industry level (Column 3, 1.2). The baseline model is estimated in Column 4 of 1.2, which includes the constitutive terms and the interaction between distance and democracy controlling for covariates at both country-industry and country levels. The results confirm the hypothesis that democracy affects the economic growth of industries differently depending on their level of technological development. Consistent with Aghion et al. (2009), all the models estimated in this paper associate *Distance from the WTF* with a positive, statistically significant coefficient. This is a robust, recurrent finding in empirical economic growth literature, suggesting that a catch-up effect might be at work in technologically backward industries (Barro and Sala-i Martin (1995), Bloom et al. (2002)).

Democracy (SVMDI) has a positive, statistically significant coefficient. However, the Equation specified in (1.1) includes interactions, so the coefficient associated with *Democracy* (β_2) cannot be considered as the final effect (Friedrich (1982), Brambor et al. (2006)). The estimates in 1.2 show that the interaction between *Distance from the WTF* and *Democracy* (β_3) is statistically significant. This means that the final effect of democracy is contingent on the technological development of industries. By the same token, the final effect of technological development on the economic performance of industries hinges upon the level of democracy.

Figure 1.1: Marginal Effects of Democracy upon Distance

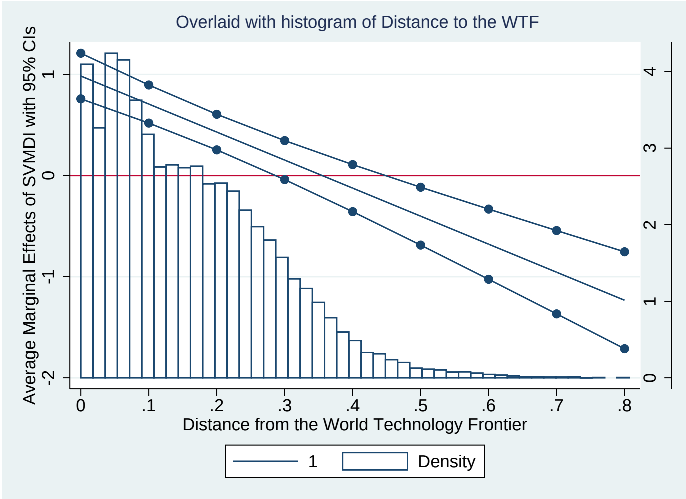


Figure 1.1 presents the marginal effects of democracy on industry growth rates (left-hand y-axis) for every 0.1 points of the variable distance from the WTF (x-axis). The histogram of the distance from the WTF is overlaid in the graph, being the y-axis on the right the density. The graph is based on the regression in Column 4 (Table 1.2), and the precise coefficients are provided in the Appendix A (Table A1.4). The figure shows that for industries that are at the WTF (a distance score of zero), the coefficient of the marginal effect is 0.98, implying that one standard deviation increase in democracy in period t increases the output growth rate of industries in period $t + 1$ by about 1.16 standard deviations[18]. This positive effect decreases as the distance from the WTF increases. The examination of these marginal effects indicates that the final effect of democracy is not significant for industries with distances from the WTF between 0.31 to 0.46. However, the estimated effect of democracy for industries beyond 0.46 points from the WTF is significant and negative, suggesting that higher levels of democracy promote a growth-diminishing effect in backward industries. Indeed, the results show that the effect of an increase in democracy of one standard deviation reduces growth rates by 0.47 standard deviations in industries 0.5 points away from the WTF.

[18]The effects are computed by multiplying the standard deviation of *democracy* and dividing by the standard deviation of the dependent variable (*industry growth rates*) shown in Table 1.

Table 1.2: Baseline Model and Alternative Measures of Democracy

Dependent variable: manufacturing industries output growth rate

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	SVMDI	SVMDI	SVMDI	SVMDI	Boix	Cheibub	Polity2	Vanhanen	Polyarchy
Distance from the WTF	1.766***	2.612***	2.360***	3.413***	2.952***	2.736***	2.314***	2.189***	3.853***
	(0.113)	(0.243)	(0.271)	(0.319)	(0.288)	(0.294)	(0.295)	(0.230)	(0.447)
Democracy	0.152***	0.478***	0.454***	0.984***	0.273***	0.139*	0.013	0.007***	-0.527*
	(0.048)	(0.083)	(0.089)	(0.115)	(0.070)	(0.073)	(0.010)	(0.002)	(0.294)
Interaction (Dist*Demo)		-1.320***	-1.452***	-2.772***	-1.896***	-1.645***	-0.133***	-0.032***	-3.416***
		(0.293)	(0.316)	(0.374)	(0.308)	(0.309)	(0.033)	(0.008)	(0.553)
Output share			-4.226***	-5.099***	-5.157***	-5.086***	-4.970***	-4.996***	-4.925***
			(0.525)	(1.028)	(1.179)	(1.021)	(1.010)	(1.008)	(0.996)
Employment			-32.640**	-32.014	-33.995	-29.706	-33.780	-30.777	-32.989
			(13.229)	(24.267)	(24.234)	(23.699)	(24.621)	(23.930)	(24.367)
Establishments			-39.226	-33.403	-26.733	-24.984	-10.440	-15.821	-30.918
			(91.052)	(98.306)	(98.525)	(99.344)	(96.787)	(98.191)	(94.730)
GDP *per capita* growth rate				0.096	0.082	0.122	0.335*	0.099	0.257
				(0.193)	(0.207)	(0.193)	(0.199)	(0.195)	(0.195)
Openness				0.001	0.000	0.001	0.001	0.002**	0.000
				(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Real exchange rate				-0.079***	-0.072***	-0.085***	-0.091***	-0.098***	-0.097***

				(0.023)	(0.024)	(0.023)	(0.023)	(0.023)	(0.023)
Regulation (Area 5 EFW)				-0.016	-0.035***	-0.007	-0.015	-0.009	-0.021*
				(0.011)	(0.010)	(0.011)	(0.011)	(0.011)	(0.011)
Population (*ln*)				-0.194	-0.584***	-0.041	-0.174	-0.039	-0.239
				(0.172)	(0.176)	(0.174)	(0.170)	(0.171)	(0.174)
Human capital				-0.073**	-0.055	-0.054	-0.068*	-0.044	-0.071**
				(0.036)	(0.036)	(0.035)	(0.036)	(0.035)	(0.035)
Age of democracy				0.000	-0.042***	-0.041***	-0.003	0.005	-0.026***
				(0.008)	(0.015)	(0.011)	(0.008)	(0.008)	(0.008)
Constant	-0.002	-0.264***	-0.039	3.183	12.124***	2.913	3.598	0.650	6.310**
	(0.040)	(0.070)	(0.078)	(2.890)	(2.965)	(2.893)	(2.844)	(2.842)	(2.980)
N of Obs.	32,550	32,550	26,974	14,037	12,428	14,037	14,037	14,037	14,037
N of Groups	3,267	3,267	2,732	2,342	2,334	2,342	2,342	2,342	2,342
Within -R^2	0.573	0.574	0.600	0.634	0.490	0.631	0.632	0.629	0.633

Clustered standard errors in parentheses at country-industry level, * $p < .1$, ** $p < .05$, *** $p < .01$

Within-group estimates using UNIDO data on 61 ISIC manufacturing industries

Year and country-industry fixed effects included but not reported

Columns 1-4 use SVMDI to measure democracy

Columns 5-9 use the Boix, Cheibub, Polity2, Vanhanen and Polyarchy measures of democracy, respectively.

The inclusion of control variables does not materially affect the result of a negative, statistically significant interaction between democracy and technology. The model in Column 4 (1.2) associates *Output share* with a negative, statistically significant coefficient. A similar result is found for *Employment*, although it turns out not to be statistically significant once country-level covariates are controlled for (Columns 4-9, 1.2). These results are consistent with the findings in Imbs and Wacziarg (2003) regarding the U-shaped relationship between sectoral concentration and economic development. *Openness* exerts only a moderately statistically significant positive effect on growth. This is consistent with Rodrik et al. (2004), who find that trade has little or no impact on growth once institutions are controlled for. *Real exchange rate* is persistently associated with a negative significant coefficient. Recall that real exchange rate is measured in terms of US dollars to local currency. These result suggests that currency overvaluations hurt the economic performance of industries, and thus provides leverage for the finding in Rodrik (2008). *Population* has a negative but not statistically significant coefficient. *Human Capital* is associated with a growth-diminishing effect. This result is consistent with Madsen (2014), who finds that educational attainment has only temporary growth-enhancing effects in aggregate growth rates[19].

In contrast with what is found in De Haan et al. (2006), *Regulation* is associated with a statistically significant negative effect on manufacturing growth. Notwithstanding these estimates at country-industry level, the overall effect of greater freedom might be positive for the economy as a whole. This finding reinforces the disaggregated approach taken here insofar as it uncovers effects of regulation that remain hidden in studies using aggregate data (Djankov et al. (2006), Jalilian et al. (2007)). Finally, the estimates find no significant effect of Boix's measure of *Age of democracy* on manufacturing growth rates when the SVMDI is used as the proxy for democracy.

Columns 5 to 9 (Table 1.2) show estimates of the baseline model using the abovementioned five alternative measures of democracy. The joint effect of democracy and distance from the WTF remains unaltered when the alternative measures of democracy are used. It is always associated with a significant, negative coefficient[20]. Thus, the estimations of these alternative models reinforce the validity of the main results and allow for comparison with other democracy-growth studies. All the models except for the one using the Polity2 index (Column 7) associate

[19]Drawing on Madsen (2014), I explore this result by including the interaction between distance from the technology frontier and human capital in the empirical model in Equation (1.1) but do find no statistical effect on disaggregated growth rates of manufacturing industries. These models are available from the author upon request.

[20]The Appendix B provide plots on the marginal effect of democracy at various levels of distance from the WTF.

democracy with a statistically significant coefficient. It should be noted that when the V-Dem measure of democracy (Polyarchy) is used the constitutive term of democracy is associated with a moderately significant, negative coefficient (Column 9). The different result of the Polyarchy measure speaks to the argument of Doucouliagos and Ulubaşoğlu (2008) that the use of alternative measures of democracy might be at the heart of the competing results in the literature.

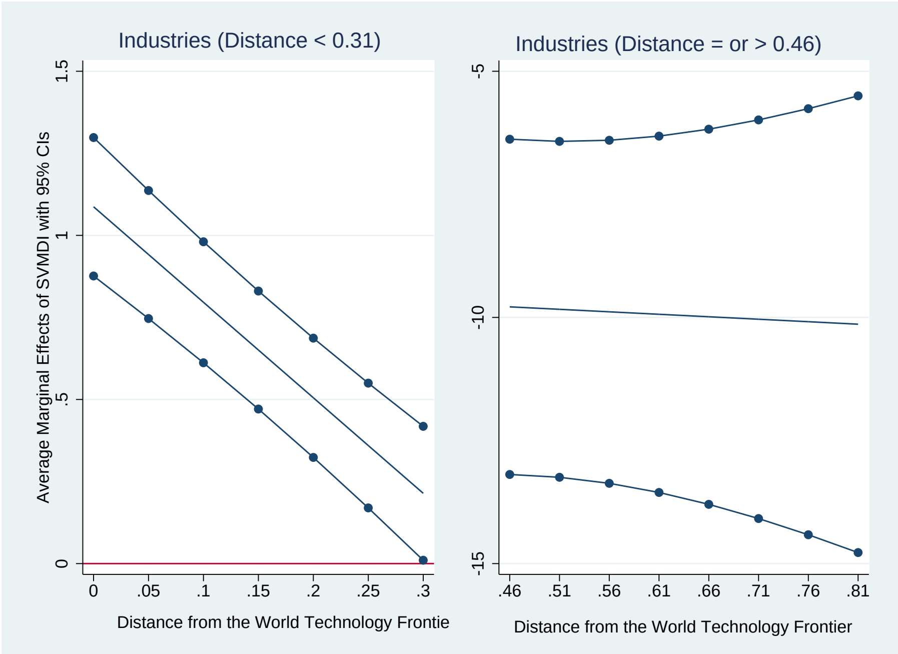
The results for the estimated effects of the controls are similar in Columns 4 to 9 (Table 1.2). However, the estimates of the duration of democracy are worth noting. *Age of democracy* is associated with a negative effect in Columns 5, 6 and 9. This finding might correspond to Olson's theory of institutional sclerosis which establishes a negative relationship between the stability of political regimes and economic growth rates. Along similar lines, Przeworski (1991) suggests that democratising countries are likely to pursue economic liberalisation reforms in the short-run but may abandon them with the passage of time. Consequently, early periods of the democratisation process might foster manufacturing growth through the liberalisation of the economy but have a negative cumulative effect over time.

1.5 Robustness checks

1.5.1 Sub-samples of the database

The main finding of this paper suggests that the effect of higher democracy scores on growth is contingent on the level of technological development of industries. For industries operating at or close to the WTF higher democracy scores lead to an increase in growth rates. However, for industries operating far from the WTF the same increase in democracy might be non-significant or even negative. Based on the estimates in Column 4 (Table 1.2), the final effect of democracy is positive and significant for industries placed at the WTF or no farther than 0.31 points from it. The effect is not significant for industries between 0.31 and 0.46 points from the WTF, whereas for industries located more than 0.46 points from the WTF the effect of increasing democracy levels is significant and negative (Table A1.4, Appendix A). This Section investigates this association by partitioning the sample of country-industries based firstly on these critical values of Distance from the WTF. Secondly, I consider industries operating in OECD and non-OECD countries separately.

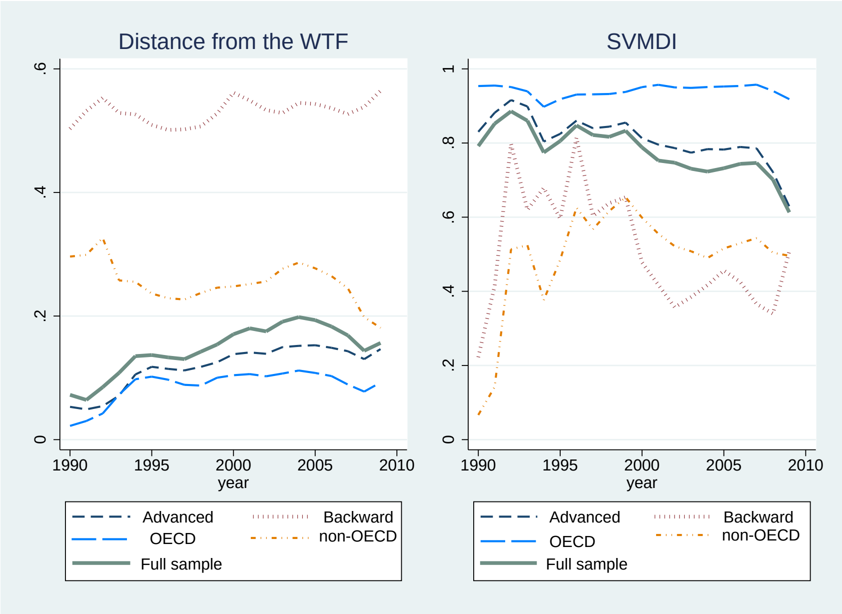
Figure 1.2: Marginal Effects of Democracy in Advanced and Backward Sub-samples



Advanced and backward industries

Figure 1.2 shows estimates of the marginal growth effects of democracy at various levels of distance from the WTF using the sub-sample of industries no further than 0.31 points from the WTF (left side) and industries that are place further than 0.46 points from the WTF (right side). Full results are relegate to Table D1.4 (Appendix D). Considering that the average distance from the WTF is 0.16, the first sub-sample of industries (Distance $<$ 0.31) covers both highly technologically advanced and backward industries, but excludes highly backward industries. The second sub-sample (Distance = or $>$ 0.46) consists of 39 industries and 17 countries. These country-industries can be found along with the summary statistics for the different sub-samples used in this Section in the Appendix D. The two samples of country-industries present highly different pictures of the mechanisms by which democracy and technological development impact on industry growth rates. As expected, the estimates that use the sample of country-industries at or no further than 0.31 from the WTF show that democracy has a positive effect on manufacturing growth that depends on technological development. This positive effect of democracy is decreasing with distance from the WTF, but democracy is always associated with a positive effect in this sub-sample. By contrast, in the cluster of industries more than 0.46 from the WTF the effect of democratisation is negative, and does not depend on the level of technological development. This growth-diminishing effect associated with democracy contributes to the argument in Acemoglu et al. (2014b) that democracy might be economically costly when certain preconditions are not satisfied.

Figure 1.3: Distance and Democracy of Sub-Samples



OECD and non-OECD countries

There are likely to be potential differences in the results arising simultaneously from varying levels of technological change and democracy. The OECD and non-OECD country groups seem to be an ideal platform to study these effects given their relatively sharp differences in their levels of development and democratic experience[21]. Figure 1.3 displays the patterns of technological development (distance from the WTF) and democracy (SVMDI) for the full sample in comparison to advanced and backward industries (which are defined in terms of the sub-samples above) as well as to OECD and non-OECD countries. The trends of technological development and democracy of country-industries at or no further than 0.31 from the WTF (Advanced, blue line) are similar to OECD country-industries (light blue line). These sub-samples have higher democracy level scores than non-OECD and backward country-industries. Regarding the level of technological development of non-OECD country-industries (yellow line), although they are closer to the WTF than the critical value of 0.46, they generally lag behind the sample average (green dash line). The sub-samples of backward country-industries and non-OECD country-industries score poorly in democracy relative to the sub-samples of advanced and OECD country-industries[22] Based on the estimates of the partitions of advanced (Distance < 0.31) and backward industries (Distance = or > 0.46) and the similarities between non-OECD and backward country-industries, one might wonder whether the link between democracy and

[21]I appreciate the suggestions of an anonymous reviewer in inspiring this Subsection.

[22]This OECD and non-OECD partition approach is further supported by the findings of Young and Tackett (2017) regarding the different drivers of labour shares in OECD and non-OECD economies.

technology in industry growth works similarly in OECD country-industries and in non-OECD country-industries.

Table 1.3 displays the results of re-estimating the baseline model for OECD countries and non-OECD countries. The growth effect of democracy contingent upon distance from the WTF is present in both OECD and non-OECD countries. However, the coefficients associated with distance from the WTF and with its interaction with democracy are higher in OECD country-industries than in non-OECD country-industries. Other differences between the estimates using OECD countries and non-OECD countries lie in the sign and significance of certain control variables. Specifically, the different results on regulation, human capital and the age of democracy shed some light on the previous results from the full sample of country-industries. The effect associated with (*Regulation (Area 5 EFW)*) is positive in OECD countries but negative in non-OECD countries. This is consistent with previous studies on the growth effect of economic and political liberalisation, in which historical and cultural environment might be crucial for the effect of economic reforms (De Haan et al. (2006)). The effect of *Human Capital* (measured by the average years of education among citizens older than 15 year-old) is found to display a significant, negative effect in non-OECD countries, but not in OECD country-industries. As suggested in Islam et al. (2014), these differential results might be driven by the large gaps in the quality of education across countries. Finally, the *Age of democracy* is associated with a growth-enhancing effect in the OECD sub-sample of countries, whereas it enters with a negative and not significant effect in the case of non-OECD countries. These different results in OECD and non-OECD economies might provide consistency to the argument of Gerring et al. (2005) that both the degree and the stock of democratic experience matter to the effect of democracy on growth also from a disaggregated industry approach.

Table 1.3: OECD and non-OECD Sub-samples

Dependent variable: manufacturing industries output growth rate		
	(1)	(2)
	OECD	Non-OECD
Distance from the WTF	8.592***	3.138***
	(2.994)	(0.345)
SVMDI	0.806*	0.849***
	(0.464)	(0.147)
Interaction (Dist*SVMDI)	-8.548***	-1.773***
	(3.142)	(0.534)

Output share	-5.941***	-4.063***
	(1.054)	(1.041)
Employment	-93.321***	-6.679
	(17.714)	(22.204)
Establishments	184.624***	-1063.442*
	(65.536)	(637.273)
GDP *per capita* growth rate	0.489*	0.468*
	(0.296)	(0.252)
Openness	0.002**	0.001
	(0.001)	(0.001)
Real exchange rate	-0.109***	-0.177
	(0.032)	(0.129)
Regulation (Area 5 EFW)	0.043**	-0.030**
	(0.021)	(0.014)
Population (*ln*)	0.593**	-0.412
	(0.259)	(0.358)
Human capital	0.099	-0.113**
	(0.067)	(0.052)
Age of democracy	0.063***	-0.004
	(0.005)	(0.008)
Constant	-15.380***	7.418
	(4.303)	(5.997)
N of Obs.	8,111	5,926
N of Groups	1,217	1,125
Within -R^2	0.742	0.564

Clustered standard errors in parentheses at country-industry level; * $p < .1$, ** $p < .05$, *** $p < .01$

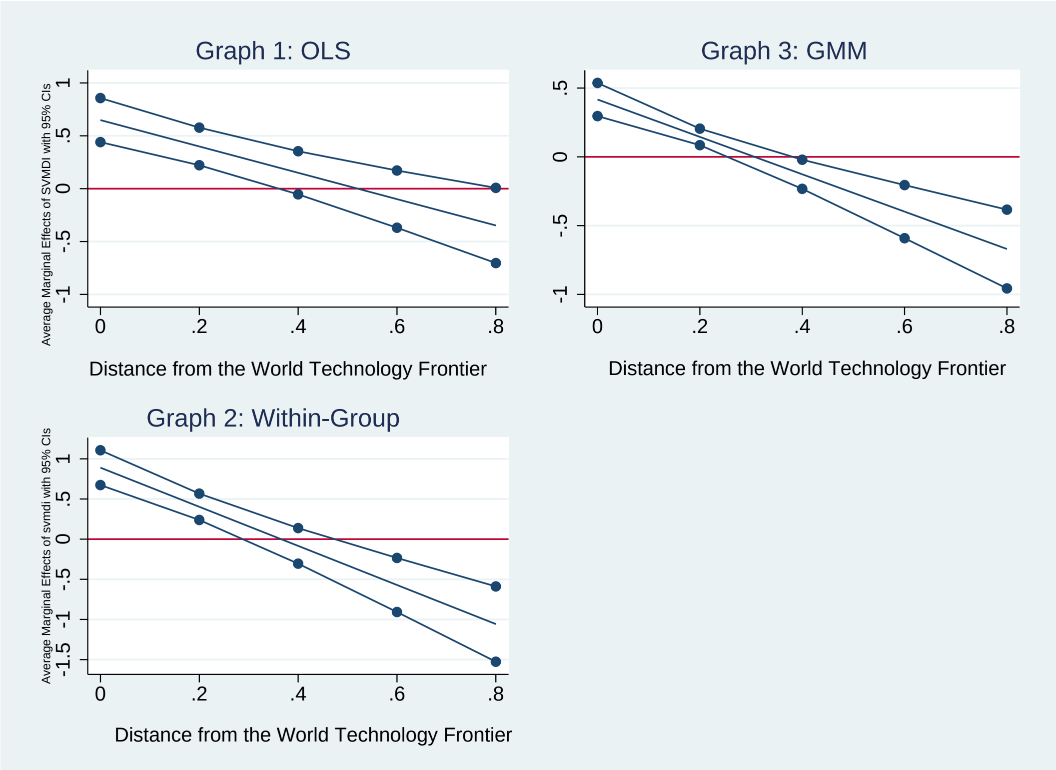
Within-Group estimates using UNIDO data on 61 ISIC manufacturing industries

Year and country-industry fixed-effects included but not reported

1.5.2 Alternative specifications and the dynamics of growth

Next, I present estimates of alternative models and estimation strategies. Figure 1.4 displays plots of the marginal effects of democracy at various levels of distance from the WTF obtained taking three alternative approaches. The full models are provided in Table D1.5 in the Ap-

Figure 1.4: Alternative Estimates of Marginal Effects of SVMDI



pendix D. The within-group approach taken in this paper is the most appropriate analysis for estimating the relationship between democracy and growth in a panel data context. However, this estimation technique demeans variables on both sides of the regression equation, and thus time invariant variables cannot be estimated. In this robustness check I build on the baseline model (Column 4, Table 1.2) and specify a regression equation which includes industry, country and year fixed effects dummies. Graph 1 (Figure 1.4) shows the final effects of democracy at different distances from the WTF based on Ordinary Least Squares (OLS) estimates. The estimates of this alternative model support the technologically-conditioned nature of the growth effect that democracy exerts on manufacturing industries.

My final robustness checks concern the level of output of manufacturing industry and the dynamics of growth. The baseline model in this paper does not include initial levels of manufacturing industry output because to do so would incur the risk of potential endogeneity issues. To alleviate this potential problem, I specify an augmented model which includes the second lag of the natural logarithm of output in each industry (*Lagged industry output (level)*). Graph 2 (Figure 1.4) displays within-group estimates of the marginal effects of democracy for different values of distance based on the augmented model. Overall, the estimates of the model that includes the initial level of output regarding the main covariates are in line with the main results.

The last step of this analysis is to specify a dynamic panel data model to analyse the cumulative effect of democracy on growth. Considering the structure of the panel dataset (large N relative to small T), including the lagged dependent variable in the set of explanatory variables might lead to the well-known Nickell bias (Nickell (1981)). I employ the system Generalised Method of Moment (sys-GMM) as developed in Arellano and Bover (1995) and Blundell and Bond (1998) to estimate this dynamic panel model. All the recommendations in Roodman (2009) concerning the implementation of the sys-GMM technique are included in the estimation procedure. The instrument matrix is collapsed so as to deal with the problem of instrument proliferation which could induce bias. The results are comparable to the main findings of this paper. However, the lagged dependent variable is not statistically significant. The post-estimation analyses validates the sys-GMM estimates, in which the number of instruments is far smaller than the number of groups, the AR test rejects the absence of first-order serial correlation but not that of second-order serial correlation. Finally, Hansen tests prove the validity of the instruments. The marginal effects of democracy in its interaction with technology are displayed in Graph 3 (Figure 1.4), which corroborates the hypothesis tested in the paper. The dynamic model ultimately confirms the interaction between democracy and technology suggested in this paper.

1.6 Conclusion

This paper tests whether the growth effect of democracy differs across industries within the same economies. The main hypothesis studied here is that the growth effect of democracy is contingent on the technological development of industries. As argued in Section 2, democracy might be more beneficial for technologically advanced industries, possibly by fostering key regulatory policies for competition and innovation, which would be relatively more important for growth in those industries. To test this hypothesis, I employ a panel dataset covering 61 ISIC industries located in 72 countries over the period 1990-2010. The results suggest that the effect of democracy on the economic performance of industries hinges upon technological development. Political regime changes towards democracy have a growth-enhancing effect on industries that are technologically advanced. By contrast, the same political changes have a growth-diminishing effect on backward industries.

The paper finds that the growth effect of democracy is contingent on the technological development of industries, and that result is robust to several sensitivity tests. First and foremost, this technologically-conditioned effect of democracy is robust to six alternative measures of democracy. The main results also hold when socio-economic and demographic factors are controlled for and when sub-samples are used in terms of technological or politico-institutional development. The regression results on the sub-sample of industries operating in OECD countries suggest that economic regulation, proxied by the EFW index, has a growth-enhancing effect. This finding is in line with the prediction in De Haan et al. (2006) that greater economic liberalisation, along with historical and cultural institutions, might be important determinants of growth rates of GDP per capita.

Taken together, these results indicate different effects of democracy from one sector to another of the economy which are contingent on technological development. The implications of this disaggregated approach enrich our understanding of the workings of political regimes by complementing existing literature on the aggregate effect of democracy. I would like to stress that these results are based on a precise definition of technological development and are limited by the availability of highly disaggregated data on manufacturing industries. There are two interesting paths along which this research could be expanded. The first entails using alternative measures of the level of technological development of industries. In this sense, the distribution of industrial robots across branches of manufacturing industry, as explored in Acemoglu and Restrepo (2017) for the US economy, might provide a bigger picture of the interplays between democracy, technology and industry growth rates. The second entails examining whether the results provided here hold for economic activities other than manufacturing industries, such as services and agriculture. These two extensions might bring striking insights, but there is an unfortunate lack of the highly disaggregated information required for a country-sector panel data analysis.

1.7 Appendix A

Table A1.1: Industries in the Sample

Processed meat,fish,fruit,vegetables,fats	Casting of metals
Dairy products	Struct.metal products;tanks;steam generators
Grain mill products; starches; animal feeds	Other metal products; metal working services
Other food products	General purpose machinery
Beverages	Special purpose machinery
Tobacco products	Domestic appliances n.e.c.
Spinning, weaving and finishing of textiles	Office, accounting and computing machinery
Other textiles	Electric motors, generators and transformers
Knitted and crocheted fabrics and articles	Electricity distribution & control apparatus
Wearing apparel, except fur apparel	Insulated wire and cable
Dressing & dyeing of fur; processing of fur	Accumulators, primary cells and batteries
Tanning, dressing and processing of leather	Lighting equipment and electric lamps
Footwear	Other electrical equipment n.e.c.
Sawmilling and planing of wood	Electronic valves, tubes, etc.
Products of wood, cork, straw, etc.	TV/radio transmitters; line comm. apparatus
Paper and paper products	TV and radio receivers and associated goods
Publishing	Medical, measuring, testing appliances, etc.
Printing and related service activities	Optical instruments & photographic equipment
Reproduction of recorded media	Watches and clocks
Coke oven products	Motor vehicles
Refined petroleum products	Automobile bodies, trailers & semi-trailers
Processing of nuclear fuel	Parts/accessories for automobiles
Basic chemicals	Building and repairing of ships and boats
Other chemicals	Railway/tramway locomotives & rolling stock
Man-made fibres	Aircraft and spacecraft
Rubber products	Transport equipment n.e.c.
Plastic products	Furniture
Glass and glass products	Manufacturing n.e.c.
Non-metallic mineral products n.e.c.	Recycling of metal waste and scrap
Basic iron and steel	Recycling of non-metal waste and scrap
Basic precious and non-ferrous metals	

61 ISIC industries from INDSTAT from UNIDO (3 digit-level 2010, rev. 3)

Table A1.2: Countries in the Sample

Albania	Czech	Indonesia	Mongolia	South
Argentina	Denmark	Iran	Morocco	Spain
Australia	Ecuador	Ireland	Netherlands	Sri Lanka
Austria	Egypt	Israel	New Zealand	Sweden
Azerbaijan	Eritrea	Italy	Norway	Switzerland
Belgium	Estonia	Japan	Paraguay	Tanzania
Bolivia	Ethiopia	Latvia	Peru	Trinidad
Botswana	Fiji	Lithuania	Philippines	United
Brazil	Finland	Macedonia	Poland	United
Bulgaria	France	Madagascar	Portugal	Uruguay
Canada	Georgia	Malawi	Qatar	Vietnam
Chile	Germany	Malaysia	Romania	Yemen
China	Greece	Mauritius	Russia	
Colombia	Hungary	Mexico	Senegal	
Cyprus	India	Moldova	Slovenia	

Table A1.3: Data Sources

Variable	Description	Data Source
Industry growth rates	Annual growth rates of manufacturing industries at 61 ISIC 3-digit level disaggregation (country-industry level)	INDSTAT 4 (UNIDO)
Distance to the World Technology Frontier	Own computation based on the definition of Acemoglu et al. (2006) (country-industry level)	INDSTAT 4 (UNIDO)
Output Share	Ratio of industry output to total manufacturing sector (country-industry level)	INDSTAT 4 (UNIDO)
Employment	Ratio of number of employees in the industry to total population (country-industry level)	INDSTAT 4 (UNIDO) & World Bank
Establishments	Ratio of number of establishments in the industry to total population (country-industry level)	INDSTAT 4 (UNIDO) & World Bank
Level of output (ln)	Natural logarithm of the level of output converted into real terms (country-industry level)	INDSTAT 4 (UNIDO)
GDP pc growth rate	Growth rate of the Purchasing Power Parity Converted GDP Per Capita (Laspeyres), measured in 2005 international dollars per person, not seasonally adjusted (country level)	Penn World Tables (mark 7.1)
Openness	Share of the sum of exports and imports of goods and services in gross domestic product (country level)	World Bank
Real exchange rate	Nominal exchange rate of the local currency to the US dollar (yearly averages) is converted into real terms using World Bank data on Consumer Price Index (2010) and inversed to provide US dollars to local currency (country level)	Clio infra (clio-infra-eu), Coppedge et al. (2016) & Word Bank
Regulation	Area 5 of the Economic Freedom of the World (EFW) index, zero to ten scores where higher values mean freer and more business-friendly environment (country level)	Gwartney et al. (2016), Fraser Institute
Population (ln)	Natural logarithm of total population (country level)	World Bank (ver. April 2014)
Human Capital	Average years of education among citizens older than 15 year-old (country level)	UNESCO & World Bank
Age of democracy	Numerical measure of consecutive years of current regime type (country level)	Boix et al. (2013)

See the Appendix B for in-depth look at the measures of democracy

Table A1.4: Average Marginal Effects of SVMDI at WTF values

Distance from the WTF	dy/dx	robust s.e.	z	p-value
0	.984	.115	8.56	0.000
0.1	.71	.096	7.36	0.000
0.2	.43	.089	4.79	0.000
0.3	.153	.098	1.55	0.120
0.4	-.124	.119	-1.05	0.295
0.5	-.401	.146	-2.75	0.006
0.6	-.679	.177 1	-3.83	0.000
0.7	-.96	.21	-4.55	0.000
0.8	-1.23	.245	-5.04	0.000

Based on sample used in model in Column 4, Table (1.2)

1.8 Appendix B

Table B1.1: Countries in the Full Sample

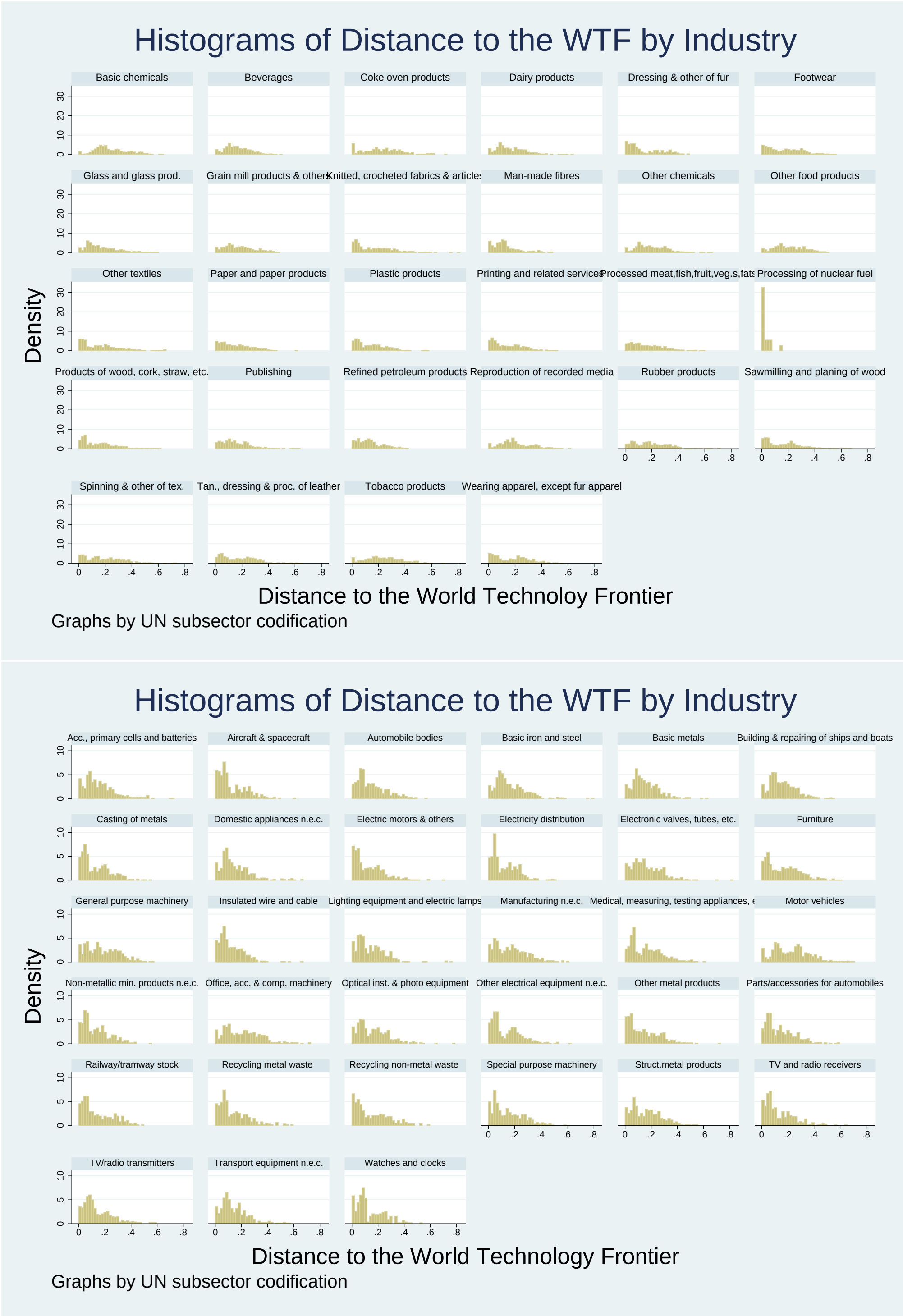
Country	Distance	Boix	Cheibub	Polity2	Vanhanen	Polyarchy	SVMDI
Albania	.30	1.00	1.00	7.63	22.24	.55	.73
Argentina	.11	1.00	1.00	7.33	26.01	.86	.86
Australia	.07	1.00	1.00	10.00	35.31	.91	.94
Austria	.06	1.00	1.00	10.00	36.42	.89	.96
Azerbaijan	.38	.00	.00	-7.00	13.53	.23	.04
Belgium	.06	1.00	1.00	9.70	43.30	.91	.93
Bolivia	.23	1.00	1.00	9.00	18.54	.76	.86
Botswana	.16	1.00	.00	8.00	9.43	.68	.82
Brazil	.15	1.00	1.00	8.00	26.90	.90	.75
Bulgaria	.31	1.00	1.00	8.62	27.71	.72	.87
Canada	.05	1.00	1.00	10.00	27.13	.88	.97
Chile	.14	1.00	1.00	8.75	21.93	.87	.94
China	.26	.00	.00	-7.00	.00	.11	.06
Colombia	.14	1.00	1.00	7.00	11.76	.50	.44
Cyprus	.13	1.00	1.00	10.00	35.88	.78	.96
Czech Republic	.22	1.00	1.00	9.85	34.60	.92	.97
Denmark	.08	1.00	1.00	10.00	43.42	.92	.94
Ecuador	.22	.75	.84	7.09	16.99	.74	.79
Egypt	.30	.00	.00	-5.05	3.03	.22	.03
Eritrea	.33	.00	.00	-6.52	.00	.09	.05
Estonia	.21	1.00	1.00	9.00	26.25	.91	.95
Ethiopia	.31		.00	-.44	4.77	.25	.09
Fiji	.26	.00	.00	2.62	18.48	.49	.63
Finland	.07	1.00	1.00	10.00	36.17	.90	.95
France	.07	1.00	1.00	9.00	31.07	.94	.97
Georgia	.39	.40	.53	5.87	11.15	.52	.37
Germany	.08	1.00	1.00	10.00	36.14	.79	.97
Greece	.11	1.00	1.00	10.00	36.48	.88	.93

Hungary	.22	1.00	1.00	10.00	30.23	.81	.96
India	.29	1.00	1.00	9.00	21.68	.74	.80
Indonesia	.27	.89	.91	5.95	18.61	.68	.52
Iran	.19	.00	.00	-1.84	3.46	.25	.08
Ireland	.06	1.00	1.00	10.00	32.16	.89	.97
Israel	.10	1.00	1.00	9.72	35.13	.77	.90
Italy	.08	1.00	1.00	10.00	39.85	.85	.94
Japan	.03	1.00	1.00	10.00	28.44	.87	.96
Latvia	.26	1.00	1.00	8.00	28.30	.87	.93
Lithuania	.25	1.00	1.00	10.00	26.09	.87	.95
Macedonia	.26	1.00	1.00	8.62	21.65	.65	.76
Madagascar	.52	1.00	1.00	7.00	12.30	.51	.71
Malawi	.34	1.00	1.00	5.88	18.47	.47	.73
Malaysia	.20	.00	.00	3.57	12.70	.34	.16
Mauritius	.21	1.00	1.00	10.00	23.27	.81	.95
Mexico	.14	.00	.10	5.58	20.44	.60	.58
Moldova	.35	1.00	1.00	8.52	15.25	.53	.44
Mongolia	.38	1.00	1.00	9.70	20.42	.76	.86
Morocco	.22	.00	.00	-6.00	4.36	.28	.15
Netherlands	.06	1.00	1.00	10.00	40.70	.90	.95
New Zealand	.03	1.00	1.00	10.00	30.29	.89	.95
Norway	.06	1.00	1.00	10.00	38.44	.92	.95
Paraguay	.21	.00	1.00	7.00	11.00	.55	.69
Peru	.25	.78	.78	7.22	17.51	.68	.74
Philippines	.21	1.00	1.00	8.00	23.23	.62	.81
Poland	.20	1.00	1.00	9.46	22.56	.88	.95
Portugal	.15	1.00	1.00	10.00	26.55	.91	.96
Qatar	.16	.00	.00	-10.00	.00	.07	.04
Romania	.30	.96	1.00	7.91	24.97	.63	.81
Russia	.25	.00	.00	5.32	20.17	.36	.13
Senegal	.25	.50	.50	3.54	7.64	.73	.48
Slovenia	.16	1.00	1.00	10.00	29.36	.81	.96
South Africa	.14	1.00	.00	9.00	11.81	.67	.78

Spain	.09	1.00	1.00	10.00	35.93	.91	.96
Sri Lanka	.27	1.00	1.00	6.00	25.30	.44	.46
Sweden	.06	1.00	1.00	10.00	37.53	.92	.95
Switzerland	.05	1.00	1.00	10.00	39.22	.93	.93
Tanzania	.30	.00	.00	-1.00	4.69	.46	.25
Trinidad and Tobago	.18	1.00	1.00	10.00	21.17	.69	.94
United Kingdom	.07	1.00	1.00	10.00	30.17	.89	.96
United States	.02	1.00	1.00	10.00	34.18	.88	.94
Uruguay	.18	1.00	1.00	10.00	32.78	.91	.95
Vietnam	.44	.00	.00	-7.00	6.00	.17	.06
Yemen	.30	.00	.00	-2.00	3.41	.32	.06

Mean country values over the period 1990-2010

Figure B1.1: Histograms of Technological Development



1.9 Appendix C

Table C1.1: Typology of Democracy Measures

Index	Components	Scale	Time coverage
Boix, (Boix et al. (2013))	Contestation and participation	dummy $0, 1$	1800-2007
Cheibub, (Cheibub et al. (2010))	Office and contestation	dummy $0, 1$	1946 -2008
Polity2, (Marshall et al. (2014))	Executive recruitment, constraints on executive authority and political competition	categorical $(-10, 10)$	1946-2013
Vanhanen, (Vanhanen and Lundell (2014))	Electoral competition and turnout	continuous (0,100) interval	1810-2010
Polyarchy, (Teorell et al. (2016))	Elected officials, free and fair election, freedom of expression, associational autonomy and inclusive citizenship	continuous (0,1) interval	1900-2015
SVMDI, (Gründler and Krieger (2016))	Aspects of political participation, political competition and civil rights	continuous (0,1) interval	1981-2011

Table C1.2: Democracy Indices Correlations

Variables	Boix	Cheibub	Polity2	Vanhanen	Polyarchy	SVMDI
Boix	1.0000					
Cheibub	0.9578	1.0000				
	(0.0000)					
Polity2	0.8615	0.8422	1.0000			
	(0.0000)	(0.0000)				
Vanhanen	0.6923	0.7031	0.7656	1.0000		
	(0.0000)	(0.0000)	(0.0000)			
Polyarchy	0.8594	0.8535	0.8975	0.8150	1.0000	
	(0.0000)	(0.0000)	(0.0000)	(0.0000)		
SVMDI	0.8896	0.8720	0.8985	0.8057	0.9378	1.0000
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	

Figure C1.1: Democracy Scores

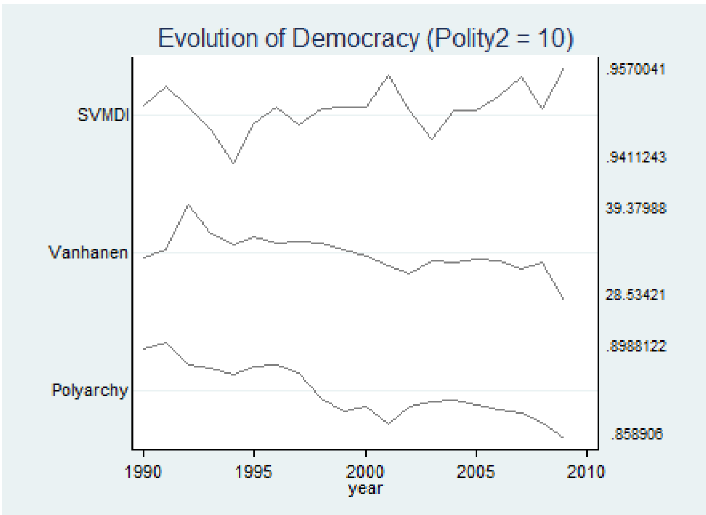


Figure C1.1 shows the evolution of average democracy scores of countries of the sample that score 10 in Polity2 measure of democracy.

Figure C1.2: Estimates Using Alternative Democracy Measures

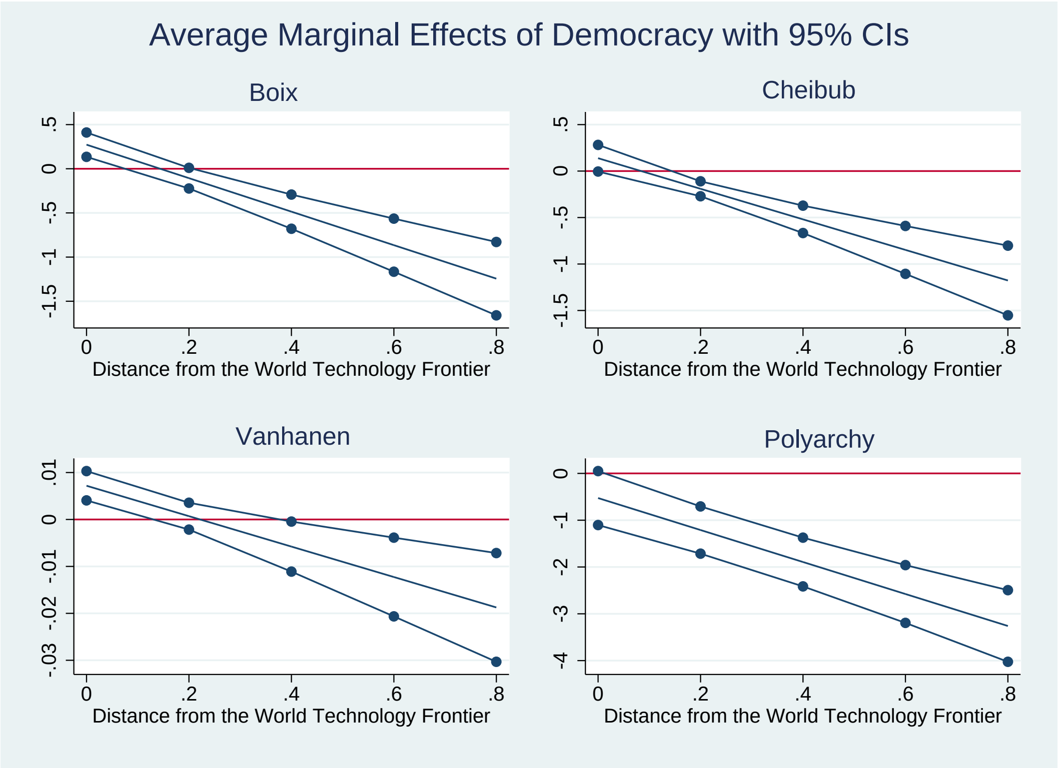


Fig. C2. Marginal effects of democracy depending upon the level of Distance from the WTF using alternative measures of democracy which correspond to models in Columns 5), 6), 8) and 9) of Table 1.2 of the main text.

1.10 Appendix D

Table D1.1: Sub-sample of Backward Industries

Accumulators, primary cells and batteries	Office, accounting and computing machinery
Automobile bodies, trailers and semi-trailers	Optical instruments and photographic equipment
Basic chemicals	Other chemicals
Basic iron and steel	Other electrical equipment n.e.c.
Basic precious and non-ferrous metals	Other food products
Beverages	Other textiles
Coke oven products	Parts/accessories for automobiles
Domestic appliances n.e.c.	Printing and related service activities
Dressing, and dyeing of fur, processing of fur	Recycling of metal waste and scrap
Electronic valves, tubes, etc.	Recycling of non-metal waste and scrap
Footwear	Reproduction of recorded media
Furniture	Rubber products
General purpose machinery	Sawmilling and planing of wood
Glass and glass products	Spinning, weaving and finishing of textiles
Grain mill products; starches; animal feeds	Struct.metal products;tanks;steam generators
Knitted and crocheted fabrics and articles	TV/radio transmitters; line comm. apparatus
Lighting equipment and electric lamps	Tobacco products
Manufacturing n.e.c.	Transport equipment n.e.c.
Medical, measuring, testing appliances, etc.	Wearing apparel, except fur apparel
Motor vehicles	

Table D1.2: Sub-sample of Countries with Backward Industries

Azerbaijan	Iran, Islamic Rep.	Mongolia
Bulgaria	Latvia	Peru
Egypt	Lithuania	Romania
Georgia	Macedonia, FYR	Senegal
India	Malawi	Tanzania
Indonesia	Moldova	

Table D1.3: Summary Statistics of Sub-samples

Variable	Mean	Std. Dev.	Min.	Max.	N
Advanced Sub-sample					
Distance to the WTF	0.139	0.086	0	0.31	12614
SVMDI	0.812	0.277	0.019	0.979	12614
Industry growth	0.234	0.468	-3.424	6.608	12614
Backward Sub-sample					
Distance to the WTF	0.529	0.065	0.461	0.77	137
SVMDI	0.448	0.353	0.022	0.958	137
Industry growth	0.524	0.765	-0.833	4.766	137
OECD countries Column 1, Table 1.3 (main text)					
Distance to the WTF	0.104	0.078	0	0.560	8111
SVMDI	0.951	0.024	0.458	0.979	8111
Industry growth	0.208	0.414	-3.424	3.38	8111
Non-OECD countries Column 2, Table 1.3 (main text)					
Distance to the WTF	0.244	0.095	0	0.77	5926
SVMDI	0.575	0.342	0.019	0.972	5926
Industry growth	0.3	0.572	-4.085	6.608	5926

Table D1.4: Sub-samples by Distance from the WTF

Dependent variable: manufacturing industries output growth rate	(1) Distance < 0.31	(2) Distance => 0.46
Distance to the WTF	3.361***	6.300*
	(0.311)	(3.320)
SVMDI	1.087***	-9.322***
	(0.108)	(2.918)
Interaction (Dist*SVMDI)	-2.910***	-1.007
	(0.352)	(4.884)
Output share	-4.610***	-21.566*
	(1.124)	(11.734)
Employment	-39.212	769.859*
	(33.482)	(391.647)
Establishments	43.153	-96064.647
	(80.960)	(91458.637)
GDP *per capita* growth rate	-0.035	9.700***
	(0.192)	(2.875)

Openness	0.001	0.002
	(0.001)	(0.015)
Real exchange rate	-0.083***	-2.118
	(0.023)	(3.004)
Regulation (Area 5 EFW)	-0.017	0.146
	(0.012)	(0.349)
Population (*ln*)	-0.357**	-6.980
	(0.176)	(6.492)
Human capital	-0.090***	-0.579
	(0.034)	(0.886)
Age of democracy	0.005	0.195***
	(0.010)	(0.043)
Constant	5.835*	114.363
	(3.046)	(103.766)
N of Obs.	12,614	137
N of Groups	2,177	77
Within -R^2	0.703	0.507

Clustered standard errors in parentheses at country-industry level; * $p < .1$, ** $p < .05$, *** $p < .01$

Within-group estimates using UNIDO data on 61 ISIC manufacturing industries

Column 1 uses a sample of highly advanced to backward industries (Distance to the WTF < 0.31)

Column 2 uses a sample of highly backward industries (Distance to the WTF = or > 0.46)

Year and country-industry fixed effects included but not reported

Table D1.4 displays the models computed to obtain the marginal effects of democracy for various levels of distance to the WTF that are shown in Figure 1.2 of the main text. Clustered standard errors in parentheses at country-industry level; * $p < .1$, ** $p < .05$, *** $p < .01$. Within-group estimates using UNIDO data on 61 ISIC manufacturing industries. Column 1 uses a sample of highly advanced to backward industries (Distance to the WTF < 0.31). Column 2 uses a sample of highly backward industries (Distance to the WTF = or > 0.46). Year and country-industry fixed effects included but not reported

Table D1.5: Country and Industry Fixed-Effects and Growth Dynamics

Dependent variable: manufacturing industries output growth rate			
	(1)	(2)	(3)
	OLS	WG	Sys-GMM
Distance	1.552***	2.841***	2.177***
	(0.227)	(0.321)	(0.231)
SVMDI	0.649***	0.890***	0.490***
	(0.106)	(0.111)	(0.062)
Interaction (Dist*SVMDI)	-1.246***	-2.435***	-1.647***
	(0.265)	(0.370)	(0.248)
Output share	-0.105	-4.011***	-0.835***
	(0.118)	(0.876)	(0.193)
Employment	-4.868*	-16.916	-5.539
	(2.824)	(18.568)	(4.598)
Establishments	2.413	113.559	45.209*
	(14.039)	(88.093)	(26.514)
GDP *per capita* growth rate	0.123	0.228	0.219
	(0.202)	(0.196)	(0.161)
Openness	0.001**	0.001	0.000
	(0.001)	(0.001)	(0.000)
Real exchange rate	-0.107***	-0.062***	-0.028***
	(0.023)	(0.023)	(0.007)
Regulation (Area 5 EFW)	-0.008	-0.010	0.053
	(0.012)	(0.011)	(0.045)
Population (*ln*)	0.022	-0.424**	-0.007
	(0.167)	(0.176)	(0.006)
Age of democracy	0.001	-0.003	0.000
	(0.007)	(0.008)	(0.000)
Human capital	-0.084**	-0.036	-0.027**
	(0.034)	(0.035)	(0.011)
Lagged industry output (level)		-0.155***	0.008*
		(0.017)	(0.005)
Lagged industry growth			-0.007

			(0.029)
Constant	-0.122	9.811***	0.404**
	(2.422)	(3.015)	(0.195)
N	14,037	14,020	14,020
N of Groups		2,342	2,342
R^2	0.617	0.648	
N of Instruments			99
AR(1) p-value			0.000
AR(2) p-value			0.106
Hansen J/Sargan p-value			0.857

Table D1.5 displays estimates of alternative models and estimation techniques as shown in Figure 1.4 of the main text. Clustered standard errors in parentheses at country-industry level; * $p < .1$, ** $p < .05$, *** $p < .01$. Estimates using UNIDO data on 61 ISIC manufacturing industries. Column 1: Pooled-OLS estimation includes country, industry and year fixed-effects. Column 2: Year and country-industry fixed effects but are not reported, within-group estimates including industry output in levels. Column 3: System-GMM estimates employing Stata's xtabond2, Stata's *collapse* option employed to avoid the proliferation of instruments.

2 — Do electoral rules affect the economic performance of manufacturing industries?

"Now if you think that proportional representation is boring, you are a very silly person because it's about how we can run the country better".

John Cleese, Monty Python's Flying Circus

2.1 Introduction

This paper investigates whether electoral rules determine the economic performance of manufacturing industries and, if so, whether this effect is heterogeneous across industries within the economies. Electoral rules convert votes into political representatives in different ways and thus result in different degrees of proportionality in parliaments. Varying degrees of proportionality might influence who controls legislative chambers, executives and policy-making in democratic countries (Pavia and Toboso, 2017). Electoral rules in legislative elections characterize two broad electoral systems: majoritarian electoral systems (MR, hereafter) and proportional representation systems (PR, hereafter). The adoption of alternative electoral systems (Boix, 1999; Benoit, 2004; Colomer, 2016) and its political consequences (Lijphart, 1990; Norris et al., 2004) have long been studied in political science. Along similar lines, the economic implications of electoral rules have also attracted scholarly attention (Knutsen, 2011; Persson et al., 2003; Rodrik, 1996). Yet there is no robust consensus on which type is more conducive to economic growth[1].

[1]See Taagepera and Qvortrup (2012) for a review of the research on political and economic effects of electoral institutions

This paper seeks to contributing to the neoclassical growth theory and constitutional political economy literatures by focusing on how electoral rules might determine the economic performance of manufacturing industries. We apply the disaggregated industry framework in Rajan and Zingales (1998) and Rodrik (2012) to specify an augmented growth model of manufacturing industries that includes political institutional settings (e.g. electoral rules) as potential determinants of economic prosperity. Previous research on the economic effect of political institutions draws broadly on aggregate economic indicators (e.g. GDP per capita growth rates at national level). We argue that studying the effects of electoral rules from a manufacturing industry approach might provide a better understanding of the workings of democratic regimes in the economy. Our approach opens up the possibility of theorizing and empirically uncovering mechanisms that might remain hidden when aggregate economic indicators are used. To the best of our knowledge, this paper is the first empirical attempt to investigate the impact of electoral rules on the economic performance of manufacturing industries in an extensive panel dataset.

Trade and industrial policies are often thought to be a politically efficient way to target key voters. However, different electoral rules provide different incentives to cater to different constituencies and thus, have different policy outcomes (Rickard, 2012a). Political scientists and pundits alike identify many different ways in which governments can privilege industries - subsidies, tax exemptions, low-interest loans, debt reduction, tariffs, and quotas. Thus, scholars find it very hard to detect the effects of electoral systems on the level of assistance to a particular industry. Furthermore, one of the attractive features of trade and industrial policy for politicians is its opaqueness, which ultimately make it more difficult for researchers to identify a causal link between electoral institutions and industry policies (McGillivray, 2004). To circumvent such difficulties, we focus on industry outcomes rather industrial policies, i.e. on the final effect that electoral rules might have on the economic performance of industries.

This paper is closely related to others that provide anecdotal evidence on the interplay between electoral rules, industry size and geographic concentration in determining which industries gain political support. McGillivray (2004) explores the cutlery industry in the United Kingdom and the United States (majoritarian systems) and in Germany (proportional representation system) in 1950-1970. The cutlery industry was similarly structured in all three countries. However, it was heavily protected by successive British governments, with high effective tariff rates, whereas the German and US governments did much less to support their cutlery industries. McGillivray (2004) argues that the joint effect of electoral rules and the geography of each industry was crucial in determining the different government assistance obtained by the industry in these different countries[2]. Along similar lines, Rickard (2012a) uses data on subsidies in fourteen countries over a twenty-year period to suggest that shared narrow interests that are geographically concentrated might obtain more political privileges under plurality rules. When interests are geographically diffuse, they might receive more political attention under more proportional systems.

We study two main hypotheses: First, we test whether electoral rules have an effect on the economic performance of industries. Second, we test the heterogeneity of this potential effect across manufacturing industries operating in the same economy. We surmise that the number of workers employed in an industry as a proportion of the total population might interact with the potential economic effect of electoral rules. As detailed in Section 2, the core of this argument is that as industries get larger they might become an attractive constituency for politicians. Politicians might target large industries by means of trade or industrial policies so as to gain the sympathy of the electorate. We predict that this mechanism would be more likely to work under majoritarian rules because such systems are found to be more prone to fostering narrow interest politics than more proportional systems (Lizzeri and Persico, 2001; Milesi-Ferretti et al., 2002; Persson and Tabellini, 2004a).

We test these hypotheses using United Nations Industrial Development Organization (UNIDO) industry-level data on growth rates in a panel of 61 industries operating in 58 economies in 1990-2010. We specify panel data models to first test for potential growth effects of majoritarian versus non-majoritarian electoral systems. Second, we test whether this potential growth effect is contingent upon varying levels of manufacturing employment. Our main result associates MR with a general growth-diminishing effect on industries. We find that this effect is contingent upon the relative size of the number of employees in an industry, meaning that majoritarian systems might display heterogeneous effects across industries within the same economies. We find that for relatively large industries MR systems are associated with a growth-enhancing effect.

The highly disaggregated approach taken in this research comes at various methodological costs. Firstly, our data does not identify the geolocation of industries in electoral districts. Thus, the claim in McGillivray (2004) and Rickard (2012b) that geographic concentration is a political

[2]The geographic concentration of the cutlery industry in the UK was crucial in its obtaining political support, in contrast to what happened to the same industry in the United States under similar electoral rules. The geographic concentration of the German cutlery industry played against its opportunities to gain political clout. The author relates this to the German electoral system type. Further insights on electoral institutions and industry privileges can be found in Martin (2015)

asset for industries under MR cannot be explicitly formulated in our analysis. Secondly, our results below might not be universally valid across all types of manufacturing activities and might be limited exclusively to the organized, formal parts of manufacturing industry[3]. Finally, other important challenges to our analysis include reverse causality, which we attempt to alleviate by lagging our explanatory variables, and the low level of variability of electoral systems within countries. Section 5 tackles this issue in depth by exploring cross-country variation and alternative, time-varying measures of electoral institutions in the form of the Gallagher index.
The rest of the paper is structured as follows. Section 2 reviews the literature and explains our main hypotheses. Section 3 presents the data employed, Section 4 shows the econometric analyses, and Section 5 conducts various sensitivity checks. Section 6 concludes.

2.2 Related literature and hypotheses

2.2.1 Electoral rules and economic growth

Constitutional political economy literature provides theoretical channels by which electoral rules might have either positive or negative effects on the economy. A polar distinction of electoral rules is made on the grounds of MR and PR. In MR elections the party that obtains a majority of votes wins the seat, whereas under proportional rules seat shares are more similar to vote shares. MR systems are usually associated with single-member-districts and smaller district sizes, whereas proportional systems have larger district magnitude. Note that throughout our research, we contrast parliaments using majoritarian rules and non-majoritarian rules. Hence, we will include proportional representation and mixed systems under the same category insofar as both lean more towards introducing minorities into a parliament.[4]. We highlight three channels derived from accountability, representation, and political stability.
The choice of electoral rules entails a trade-off between accountability and representation (Persson and Tabellini, 2005; Carey and Hix, 2011). On the one hand, MR is found to be more accountable since the electorate is better able to identify poorly performing politicians and vote them out of office (Benhabib and Przeworski, 2010; Powell Jr and Whitten, 1993). PR systems are generally associated with coalition governments, where voters find it more difficult to pinpoint politicians to blame and vote them out due to the party-list voting system. In

[3]As explained by Rodrik (2012), the UNIDO industrial statistics database is derived largely from industrial surveys, and informal firms are often excluded from such surveys.

[4]We use alternative models which are relegated to supplementary materials that separate proportional and mixed systems. The results show no significant differences.

this sense, retrospective economic voting would bring better economic performance under MR than PR parliaments (Knutsen, 2011). On the other hand, the higher representation under PR might offset the potential negative effects from of the relative lack of accountability. Higher proportional representation of the electorate makes parliaments more inclined to implement universal redistribution programs. Indeed, PR is found to appeal to a broader electorate than MR and to implement broad-based public spending programs -universal education and public health- which lead to higher economic growth. As regards representation, PR therefore seems more likely to foster economic growth than MR.

An additional channel for considering a potential growth-enhancing effect of PR is political stability. Majoritarian democracies produce abrupt changes in the composition of parliaments before and after elections, but proportional systems provide longer periods of office and softer changes or adjustments in policies (Rogowski, 1987; Lijphart and Aitkin, 1994; Knutsen, 2011). In that sense, PR systems might provide more political stability, thus fostering investment and innovation, in contrast to political alternations due to drastic electoral shifts under MR parliaments.

The empirical literature on the growth effect of electoral rules is still inconclusive, though some insights suggest that more proportional systems might benefit economic growth. Lijphart (2012) finds a small but positive effect of PR on GDP growth rates. Consistently with this, Persson (2005) provides cross-sectional and panel data evidence that reforms turning authoritarian political regimes into parliamentary, proportional, permanent democracies seem to foster the adoption of more growth-promoting structural policies. Knutsen (2011) uses a cross-country analysis of a sample of 107 countries and finds that PR systems produce a greater economic growth. Knutsen argues that PR systems tend to generate broad-interest policies -universal education spending, property rights protection and free-trade- rather than special interest economic policies. We depart from this literature by digging deeper into the impact of electoral rules on economic performance at industry level which enables us to study whether electoral rules have different effects within economies.

2.2.2 Majoritarian rules and the number of manufacturing workers

Even thought the contribution of this research is empirical, we conjecture a mechanism that builds upon the theoretical strand of constitutional political economy literature. Milesi-Ferretti et al. (2002) and Persson and Tabellini (1999) show how electoral rules -by determining the proportionality of votes to seats in parliaments-, influence policy-making, and thus the composition of government spending. Persson, Roland and Tabellini (2003, 2005) suggest that electoral systems shape the incentives of politicians to implement broader or narrower spending programs: more proportional elections are found to produce higher public spending and to tilt it towards general electorate and universalistic welfare programs. By contrast, majoritarian elections tend to produce lower public deficits and lower consumer prices (Carey and Hix, 2013). These stylized facts on electoral systems and public spending can be seen in two ways: through district magnitude and electoral rule (Persson and Tabellini, 2004). As regards district magnitude, majoritarian elections are conducted in smaller districts, which might induce politicians to target smaller groups, probably in geographic-based constituencies. However, in PR systems districts are larger, which encourages politicians to seek the support of a broader group of the electorate.

The minimal coalition of voters needed to win the election under MR is smaller than under PR or a mixed system, since a party can win an election with one quarter of the national vote (half of the votes in half of the districts) (Persson and Tabellini, 2004a). By contrast, under PR systems it needs half the national vote to win office, which lead politicians to seek the support of larger segments of the electorate. Unsurprisingly, well-established evidence on the economic consequences of electoral rules is that PR systems produce policies serving broader interests than MR.

A straightforward implication of the literature to date is that under MR politicians tend to favour industrial, geographically concentrated interests at the expense of broader, geographically dispersed public interests McGillivray (2004); Rickard (2012a). Our paper hypothesizes that the use of industrial policy as an electoral tool might be more salient in MR countries. That being the case, we should find a significant association between majoritarian rules and industry growth rates. Furthermore, we consider that this mechanism might be contingent upon the level of employment of industries. Industries that employ a higher proportion of the electorate, measured in terms of the number of employees in each industry as a proportion of the total population, might be more liable to obtain political protection. Consequently, we surmise that whatever the effect of majoritarian rules on the economic performance of industries may be, it should vary as industries employ a higher proportion of the electorate[5].

The actual size of the industries in the sample and the extent to which industrial policy can

[5]In a sense, our conjecture is reminiscent of the literature on special interest politics (Grossman and Helpman, 2001) and collective action (Esteban and Ray, 2001). Thus, it might be considered that large industries are better able to lobby thanks to their large number of employees or their higher relative weight in the economy as a whole. However, the absence of data on lobbying efforts for our highly disaggregated approach constrains our ability to further test for a potential lobbying-based explanation.

be seen as a narrow or a broad interest may be called into question. Generally speaking, a single industry employs a rather small portion of the total electorate, so their interests might not be taken into account as targets of general-public politicians. As shown below, the sample average size of industries is 0.1% of the population, with the maximum being 6% for *wearing apparel, except fur apparel* industry in Mauritius in 1998.

2.3 Data

We construct an unbalanced panel dataset consisting of 22,458 observations of 61 International Standard Industrial Classification (ISIC) industries operating in 58 countries in 1990-2010. We collect information on industries from the UNIDO Industrial Statistics Database (INDSTAT4) at a 3 digit-level (2010, revision 3). UNIDO provides data on manufacturing output in current international US dollars that we convert into real US dollars, which we converted into real US dollars terms (constant 2010). Our dependent variable is the annual growth rate of output of industry i in country c over a year t.

Data on electoral systems is collected from Bormann and Golder (2013), who provide information on 212 democratic national-level lower-chamber legislative elections in the 58 countries in 1990-2010. All the countries included in the sample are classified as democratic regimes in the sense of Przeworski (2000) [6]. The vast majority of them are parliamentary democracies, and the rest are semi-presidential and presidential democracies. Our classification of electoral rules follows Golder (2005), with electoral systems typified in three categories: majoritarian, proportional representation and mixed systems. Table A2.1 in the Appendix lists our sample countries by electoral systems, and includes the electoral switches in certain countries and the years in which those changes took place. Following Bormann and Golder (2013), we construct a dichotomous variable which equals one if legislators are elected on the basis of majoritarian rules and zero otherwise. For non-electoral years, we enter the same value of the previous electoral year. Subsequent sections describe the control variable sets used in our empirical investigation, and Table A2.3 in the Appendix shows our data sources.

[6] A regime is deemed democratic when the following conditions hold simultaneously: i) the chief of the executive is elected; ii) the legislature is elected; iii) there is more than one party running for election; and iv) an alternation under the identical electoral rule has taken place.

Table 2.1: Summary Statistics

Variable	Mean	Std. Dev.	Min.	Max.	N
Growth Rate	0.093	0.529	-6.144	6.608	18110
Industry Employ	0.001	0.002	0	0.063	18110
Share VA	0.02	0.028	0	0.616	18110
MR	0.165	0.371	0	1	18110
GI	6.55	5.536	0.26	33.25	18033
ENEP	4.801	1.732	2.1	11.51	4180
Growth Manu	0.131	0.396	-1.009	1.428	15601
Manu Employ	0.062	0.026	0.002	0.14	18110
Manu (ln)	24.65	2.043	18.392	29.025	18110
GDP pc	0.026	0.034	-0.157	0.13	18110
Human Capital	0.996	0.181	0.161	1.566	18110
Civil Liberties	6.284	0.873	3	7	18110
Population	16.597	1.528	13.757	20.884	18110
Trade	73.935	32.235	16.75	175.174	18110
Tariffs	3.77	4.231	0.11	32.75	18110
RER	0.631	0.566	0	2.097	18110
Area (ln)	12.25	1.588	7.616	16.031	18110

2.4 Empirical analysis

2.4.1 Specification

We specify the following fixed-effects panel data model to test whether majoritarian rules have an effect on the economic performance of industries. Furthermore, we hypothesize that their potential effect might be contingent upon the relative size of industry in terms of workers as the proportion of the total population ($IndustryEmploy_{ict}$).

$$Y_{ict} = \beta_0+\beta_1 MR_{ct}+\beta_2 IndustryEmploy_{ict}+\beta_3 MR_{ct}*IndustryEmploy_{ict}+X_{ct}\gamma+\alpha_i+\delta_c+\mu_t+\epsilon_{ict} \quad (2.1)$$

$$Y_{ict} = log(Y_{ic,t+1}) - log(Y_{ict})$$

$$i = industry, c = country, t = year$$

where the dependent variable is the annual growth rate of output in industry i in country c and year t, measured in log differences. We computed the dependent variable with the log difference of output in $t + 1$ and t while all explanatory variables are lagged one year with respect to growth rates to alleviate possible reverse feedback issues. We place special emphasis on the explanatory variables MR_{ct} (which is a dichotomous variable which takes a value of one for majoritarian electoral rules and zero otherwise), $IndustryEmploy_{ict}$ (which measures the size of industries in terms of number of workers as a proportion of total population), and the interaction between these two variables. A significant coefficient associated with the interaction (β_3) would mean that the effect exerted by majoritarian electoral rules on industry growth rates varies with the relative proportion of industry workers in the total population. The term X_{ct} is a set of control variables, the yearly fixed effect μ_t, industry α_i and country (δ_c) fixed effects. ϵ_{ict} is the error term which is assumed to have zero mean.

2.4.2 Control variables

We control for country-level economic development ($GDPpc_{ct}$) and the log of the output of the total manufacturing sector ($Manu_{ct}$), both in real terms (constant US dollars, 2010). We include the level of education of the population ($HumanCapital_{ct}$) to control for human capital externalities in both economic growth and political dimensions, such as political stability and the civil monitoring of policy-making (Lucas, 1988b; Glaeser et al., 2004; **?**). We also control for different levels of institutional quality which could either shape the political process in a country or determine the industry growth rates. Based on the Freedom House rating of civil liberties ($CivilLiberties_{ct}$), we include a re-scaled variable of the original rating which ranges from 1 (the lowest of civil liberties) to 7 (the highest)[7].

Our set of controls also expands on previous findings on the interplays between electoral systems and population size (Rogowski, 1987; Rokkan, 1970a; **?**) by including the log of the total population ($Population_{ct}$). Additionally, the electoral rule may have important implications for trade policy and trade openness (McGillivray, 2004; Rickard, 2012b). In particular, Kono (2009) states that the nature of electoral institutions makes politicians more responsive to narrow protectionist interests and, consistently with Rogowski (1987), he associates trade openness with PR systems. We control for trade openness ($Trade_{ct}$) - measured by the ratio of the sum of exports and imports to GDP - and tariffs on manufacturing products ($Tariffs_{ct}$) to minimize the possibility of reporting a spurious correlation between electoral rules and the economic performance of manufacturing industries. We acknowledge that trade policy may be in fact a kind of favouritism in that higher tariffs may reflect a tendency to protect local

[7]We also set up models including alternative measures of democracy. Drawing on Knutsen (2011), we considered the Polity2 composed index collected by the Polity IV Project, which produces results similar to those shown in the paper. The alternative models are available upon request.

industries. Its inclusion may capture some of the favourable effect on the industry growth. In addition, we control for the real exchange rate of the local currency to US dollars (Rodrik, 2008).

Finally, we control for the size of the countries (log of land area in sq. km, World Bank). Geography might crucially determine the economic outcome of alternative electoral rules (?McGillivray, 2004; Rickard, 2012a). Our disaggregated approach is highly constrained by the scarcity of data on the geographic location of manufacturing industries (e.g. region or electoral district). One possible way of offsetting potential interplays between electoral rules and the location of industries is to control for the size of countries.

2.4.3 Results

Table 2.2 shows fixed effects estimates suggesting that electoral systems are associated with a growth-diminishing effect in industries that hinges upon the number of workers to total population employed in an industry. Column 1 only includes the dichotomous measure of majoritarian or proportional/mixed systems (MR_{ct}), the size of the industry, the level of manufacturing output and real GDP per capita growth rates. MR enters with a negative and significant coefficient, a result that we explore in depth in the following models.

The relative size of industry employees ($IndustryEmploy_{ict}$) is associated with a negative effect in growth rates. This result might be interpreted along the lines of recent scholarship on technological change in manufacturing industries. Acemoglu et al. (2014a) focus on U.S. manufacturing data to relate productivity increases, when detectable, with declines in employment. However, the existing literature is mainly focused on developed countries and specifically on the US economy. As argued in Brynjolfsson and McAfee (2012), U.S. workplaces have been, and will continue to be, automated and transformed by information technology (IT) capital. The IT transformation, authors predict, will unleash major productivity increases in all sectors, and particularly IT-intensive sectors and IT-powered machines will replace workers, leading to a substantially smaller role for labour in the workplace of the future. Displacement of the production and the interplay with international trade and protection Pierce and Schott (2016) can also be at work in this growth-diminishing effect of higher employment of industries [8]. Ultimately, this finding adds to the work of Rodrik (2012), who considers a lower level of data disaggregation (23 industries per country, whereas our data covers 61 industries per country).

[8] For further insights on this result see Imbs and Wacziarg (2003).

Table 2.2: Majoritarian Rules and Industry Annual Growth Rates

	(1) WG	(2) WG	(3) WG	(4) WG	(5) WG
MR	-0.193***	-0.245***	-0.205***	-0.202***	-0.212***
	(0.033)	(0.035)	(0.029)	(0.027)	(0.030)
Industry Employ	-44.071***	-55.119***	-69.308***	-35.453***	-34.256***
	(10.992)	(10.972)	(13.103)	(9.276)	(9.322)
Manu (ln)	-0.088***	-0.091***	-0.150***	-0.165***	-0.165***
	(0.024)	(0.024)	(0.020)	(0.020)	(0.020)
GDP pc	0.559***	0.556***	0.367***	0.393***	0.392***
	(0.123)	(0.124)	(0.136)	(0.132)	(0.132)
MR * Industry Employ		53.371***	69.291***	67.430***	58.513***
		(10.496)	(12.396)	(8.801)	(11.248)
Human Capital			0.153***	0.144***	0.144***
			(0.029)	(0.030)	(0.030)
Civil Liberties			-0.010	-0.000	-0.000
			(0.007)	(0.007)	(0.007)
Population (ln)			0.270**	0.206*	0.206*
			(0.121)	(0.114)	(0.114)
Trade			0.003***	0.003***	0.003***
			(0.000)	(0.000)	(0.000)
Tariffs			-0.006***	-0.007***	-0.006***
			(0.002)	(0.002)	(0.002)
RER			-0.001	-0.010	-0.010
			(0.009)	(0.009)	(0.009)
Area (ln)			0.680	0.706	0.708
			(0.544)	(0.525)	(0.525)
Share VA				-4.898***	-5.067***
				(0.715)	(0.806)
Share VA * MR					1.310
					(1.238)
Constant	2.140***	2.240***	-9.326	-8.206	-8.236
	(0.565)	(0.564)	(7.372)	(7.057)	(7.051)

N of Obs.	22,458	22,458	18,110	18,110	18,110
No. of Groups	2,454	2,454	2,223	2,223	2,223
log-likelihood	-6340.378	-6321.511	-3275.127	-3144.482	-3143.342
Within R-squared	0.627	0.628	0.670	0.674	0.674
Between R-squared	0.146	0.137	0.007	0.009	0.009
Overall R-squared	0.489	0.484	0.085	0.092	0.091

Withing-group estimates using as dependent variable annual growth rates of manufacturing industries

Clustered standard errors in parentheses (country-industry level)

* $p < .1$, ** $p < .05$, *** $p < .01$

Year fixed effects included but not reported

Column 2 includes the interaction between MR and size of industries, and is associated with a positive and significant effect. However, these results can be driven by omitted industry or country-specific factors. Column 3 controls for a wide variety of industry-specific and country-level covariates. The most important feature is that throughout the whole analysis, the coefficients associated with MR, the size of industries and the interaction between these two constitutive terms remain unaltered. Consistent with Knutsen (2011) and Persson and Tabellini (2004a), our findings suggest that electoral rules might play a role in economic growth. Our disaggregated approach shows indeed that electoral rules might have a heterogeneous effect within economies. The interplay between plurality electoral rules and the relative size of industry workers seem to affect the annual growth rates of manufacturing industries.
Column 4 explores whether the initial share of value added of industries to total manufacturing sector ($Share_{V}alueAdded_{ict}$) matters to the economic performance of industries. By doing so, we attempt to control for convergence-type effects in industry growth (see Rodrik (2012) for a further insight). From a political economy literature viewpoint, the inclusion of the share of value added helps to control for the financial ability of industries. Put it differently, we try to keep constant the ability of industries to persuade policy-makers. However, since there is no available data on the lobbying effort at our disaggregated level of manufacturing industries, we cannot formulate a proper channel nor an argument based on the lobbying capacity of industries. The share is associated with a negative sign, which is consistent with the convergence hypothesis that lower value added industries might have more potential (Barro and Sala-i Martin, 1997). Column 5 tests the possibility that the effects that MR exerts on the economic performance of industries is not only contingent upon the weight of industry workers

to total population, but also differs at varying levels of share of value added. However, it turns out that the interaction between (MR_{ct}) and the share of value added is not significant, and consequently, our preferred model is the one in Column 4.

Figure 2.1: Marginal Effects of MR

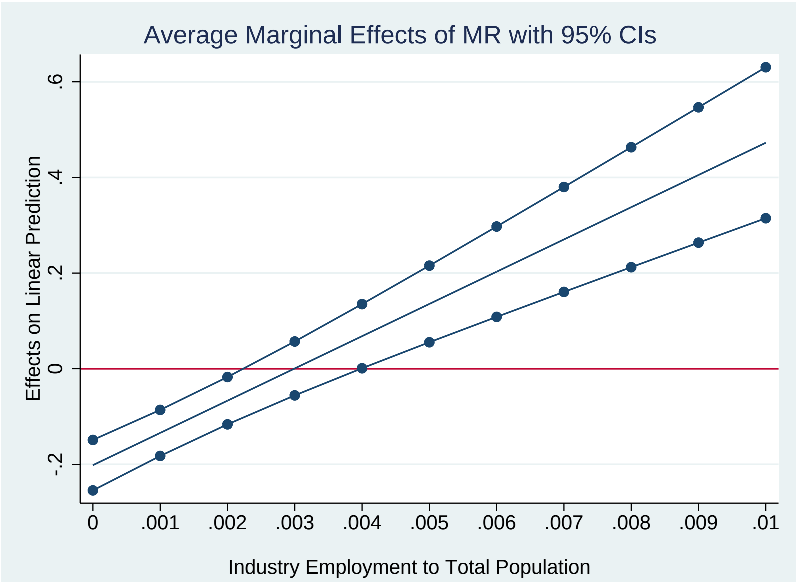


Figure 2.1 plots in the left y-axis the marginal effects of MR at various levels of the weight of industry employees to total population ($IndustryEmploy_{ict}$) (x-axis)[9]. To better display the effects, the figure shows marginal effects of MR for industries that gather small portions of the population to 1%. These marginal effects are computed based on the preferred model (Column 4, Table 2.2). MR is found to generally exert a growth-diminishing effect in industry growth rates, although for big industries, the effect is growth-enhancing. Recall that the average $IndustryEmploy_{ict}$ of the sample is 0.1%. Changing from non-majoritarian into a majoritarian system would lead to a reduction of 0.13% of annual growth rates of average size industries. However, for industries that employ beyond a 0.3% of the population, the effect of MR is positive. Institutional changes towards MR would increase by 0.4% annual growth rates of industries that employ around 1% of the population.

2.5 Sensitivity checks

2.5.1 Disproportionality in parliaments

Taagepera and Qvortrup (2012) warn that dichotomous characterizations of majoritarian versus

[9]See Table A2.6 in the Appendix for exact values of marginal effects and Figure A2.1 for a representation of marginal effects over the whole sample of industries.

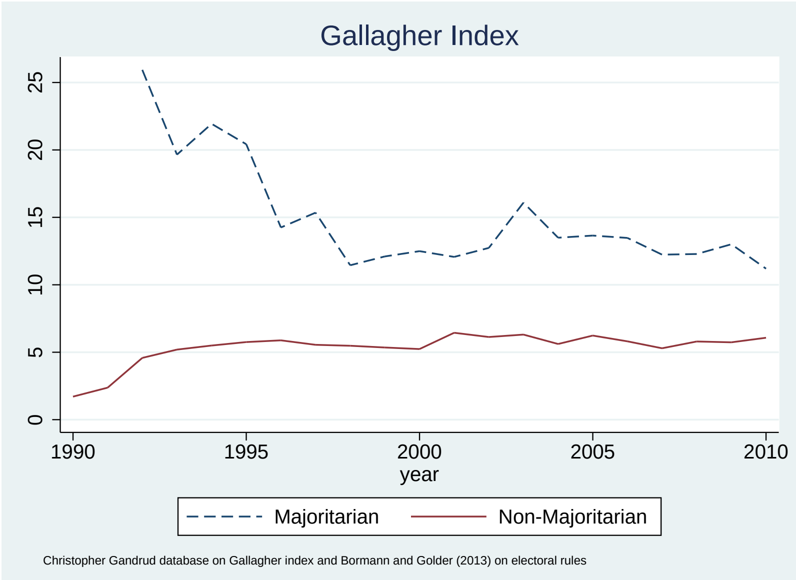
proportional systems fall short to capture potential overlapping institutional features across electoral systems. We check the robustness of the results above by considering alternative measures of electoral institutions that present higher variability across time and within electoral rules. We first replicate our preferred model (Column 4, Table 2.2) using the Gallagher index of disproportionality (GI, henceforth). The GI index is widely used to measure disproportionality in parliaments (Gallagher, 1991), in which generally, majoritarian systems obtain higher scores (i.e. more disproportionality). The index is computed as follows:

$$GI_{ct} = \sqrt{\frac{1}{2}\sum(v_i - s_i)^2}$$

where v_i is the share of votes in legislative elections and s_i the share of seats in parliament of each political party ($i = 1, ..., n$ political parties). The GI index provides the percentage of disproportionality between vote and seats in parliaments. Theoretically, it can span a 0-100% interval, where the lower the value, the higher the proportionality of parliaments. In our sample data, the GI index goes from 0.26% (South Africa, 2004) to 33.25 % (Mongolia, 2006). The GI index is collected from Christopher Gandrud database.

Scholarly wisdom associates majoritarian rules with more disproportional parliaments. Figure 2.2 shows the evolution of average GI index by majoritarian and non-majoritarian countries of our sample. Over the period 1990-2010 there is a convergence between these two types of parliaments, although non-majoritarian countries are clearly more proportional in terms of GI index than majoritarian countries. The average GI index for the former countries is 5.34% while for the latter is 14.94%.

Figure 2.2: Evolution of Disproportionality

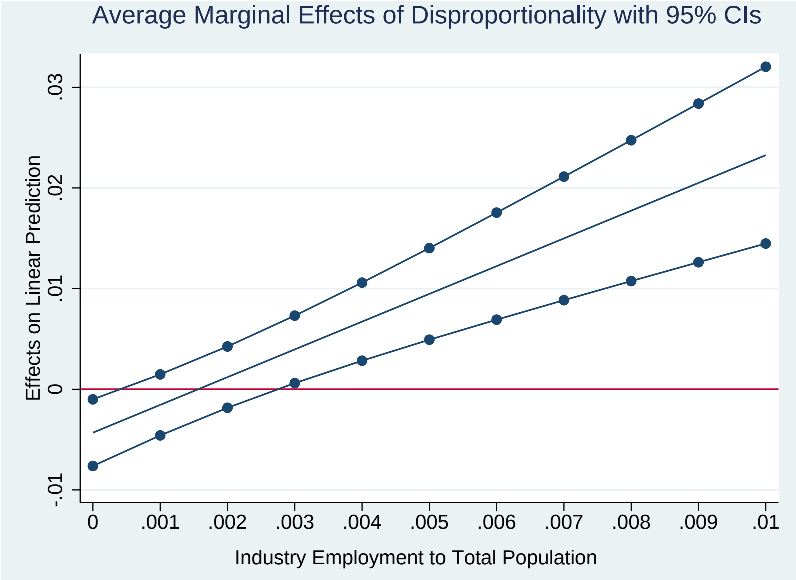


Based on the results of Section 4, our prior is that higher levels of disproportionality should be significantly and negatively associated with annual growth rates of industries. Fixed-effects results reveal that this is indeed the case, as GI index is associated with a negative and significant coefficient (Column 1, Table A2.4 in the Appendix). This result is consistent with Alfano and Baraldi (2014), who find a negative growth effect associated to increasing levels of the GI index in an aggregate context. The interaction between disproportionality and industry employment is associated with a significant, positive coefficient. This finding means that for average size industries, higher disproportionality grinds the economic performance of manufacturing industries. However, as industries get larger, this effect turns out to be positive.

Figure 2.3 plots the marginal effects of one additional percentage point of GI index for different industry employment values[10]. For average size industries (employing around 0.1% of the population), the point estimate implies that one standard deviation increase in GI index last year decreases growth rates of these industries by 0.4 standard deviations (sd). The critical industry size beyond which increasing disproportionality exerts a growth-enhancing effect is .16%. For industries that employ at least 1% of the population, the same increase in disproportionality, to the contrary, increases growth rates by 0.2 sd.

[10]Figure A2.2 and Table A2.7 in the Appendix show precise values of marginal effects over the whole sample.

Figure 2.3: Marginal Effects of Disproportionality



2.5.2 Effective number of political parties

The next step of our sensitivity analysis employs the effective number of political parties as an alternative measure of electoral rules. The number of parties is an endogenous political factor of electoral systems which varies across countries and time (Taagepera and Qvortrup, 2012; Carey and Hix, 2013). As the Duverger's law states, proportional representation systems provide the electoral conditions to fostering the existence of many parties, whereas a majoritarian system restrict the number of political parties, generally resulting in a two-party system (Duverger, 1986). The effective number of parliamentary legislative parties (ENEP hereafter) is computed as follows:

$$ENEP_{ct} = \frac{1}{\sum s_i^2}$$

where s_i is the percentage of legislative seats won by the i party. The measure corrects for independents or "other" parties as provided in Laakso and Taagepera (1979)[11]. The data is collected from Bormann and Golder (2013). We replicate our preferred model (Column 4, Table 2.2) including the ENEP measure rather than the dichotomous variable MR (see Column 2, Table A2.4) in the Appendix). The result on the industry employment remains significant and

[11] As explained in Bormann and Golder (2013), the "corrected" measure of Taagepera (1997) uses a method of bounds. It essentially requires calculating the effective number of parties treating the 'other' category as a single party (smallest effective number of parties), then recalculating the effective number of parties as if every vote in the "other" category belonged to a different party (largest effective number of parties), and then taking the mean.

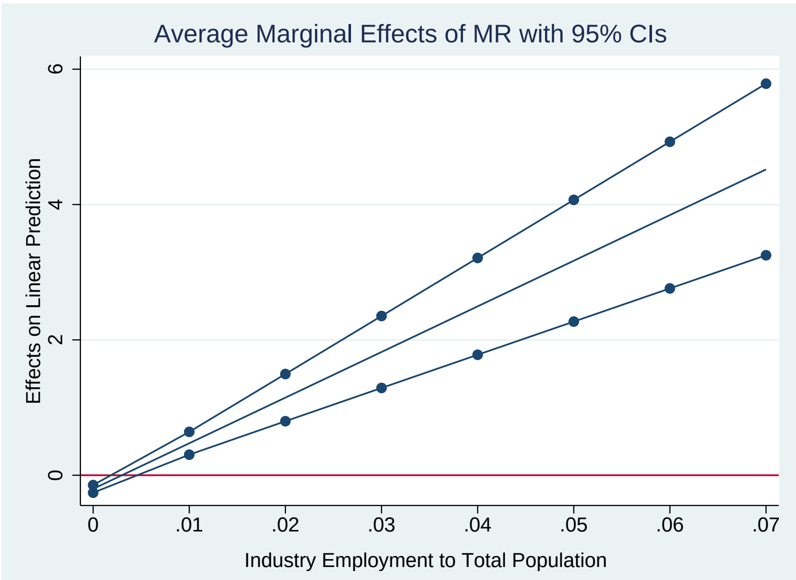
negative. However, the ENEP is not associated with a significant effect, which reinforces our focus on the role of proportionality of parliaments in determining the economic performance of industries[12].

2.5.3 Between-country variation and 5-yrs growth rates

The next sensitivity check specifies a model which includes country and industry fixed effects and estimate it using pooled Ordinary Least Squares (OLS). Figure 2.4 plots the marginal effects of MR at various levels of the ratio of industry workers to total population based on the results of regression in Column 3, Table A2.4 in the Appendix. The results are similar to the estimates of our preferred fixed effects model.

We also consider using as dependent variable longer-term growth rates of industry output.

Figure 2.4: Marginal Effects of MR (OLS)



We compute 5-years growth rates, and run against our main explanatory variables as well as the set of controls. We find that the effect of MR remains. Majoritarian rules are associated with a negative and significant coefficient. Similarly, the interaction is significant and positive, which confirms the robustness of the results at annual growth rates (see Column 4, Table A2.4 in the Appendix).

[12]Brambor et al. (2006) shows the inaccuracy of conclusions drawn on the basis of the significance of the interaction term when the constitution term at stake is not significant.

2.5.4 Aggregate level

We propose a final sensitivity check that employs an aggregate model of economic performance of the total manufacturing sector (Equation 2.2). One might consider a country-year level specification as a weighted regression of the model in Equation (2.1), being the weights the relative size of each industry i within country and time spells. We therefore check the robustness of our previous results by considering that if majoritarian rules and the share of workers to total population are important predictors of disaggregated industry growth, we should also see similar effects at country-level data[13].

$$Y_{ct} = \beta_0 + \beta_1 MR_{ct} + \beta_2 ManuEmploy_{ct} + \beta_3 MR_{ct} * ManuEmploy_{ct} + X_{ct}\gamma + \mu_t + \delta_c + \epsilon_{ct} \quad (2.2)$$

$$Y_{ct} = log(Y_{c,t+1}) - log(Y_{ct})$$

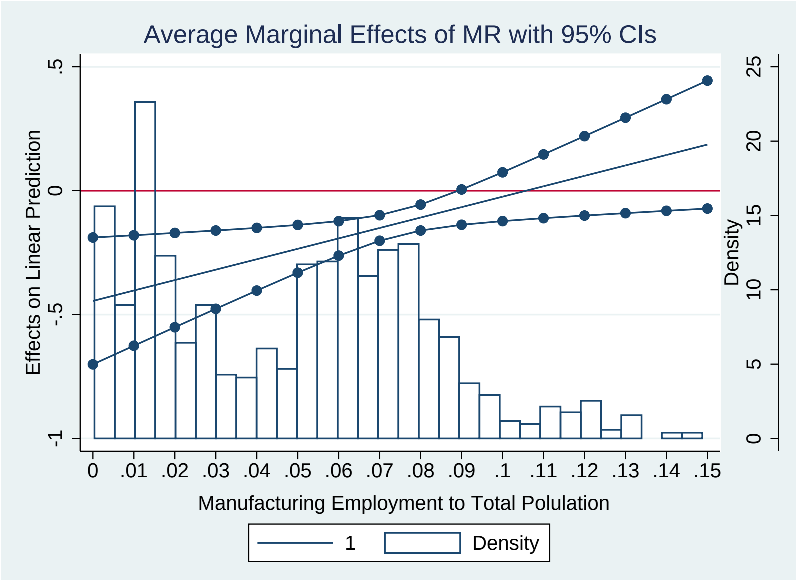
$$c = country, t = year$$

where Y_{ct} is the annual growth rate of output of total manufacturing industry in real terms (constant US dollars, 2010), μ_t year fixed effects, δ_c time-invariant characteristics and ϵ_{ct} denotes the error term. $ManuEmploy_{ct}$ is the ratio of workers in the manufacturing sector to total population, that ranges from 0.2% to 14%. The data is also collected from the UNIDO database. As regards the explanatory variables, the definitions and sources provided above apply for the data included in these models. Fixed-effects estimates on models with and without the full set of controls are provided in Table A2.5 in the Appendix. In all these models, our main explanatory variables (MR_{ct} and $ManuEmploy_{ct}$) and the interaction between them are associated with a statistically significant effect, and the sign are the same as found in the country-industry level specification.

Figure 2.5 overlaps the marginal effects obtained in the model (**??**) (y-axis) with the histogram of the ratio of total manufacturing employment to total population (x-axis) (see Table A2.8 of the Appendix for exact values). The interpretation goes along similar lines as our main finding. We find that institutional changes towards majoritarian rules are associated with a growth-diminishing effect in the total manufacturing sector. Nevertheless, this negative effect

[13] Recall that due to data coverage, the aggregate analysis is based on 49 countries. The countries that are missing at the aggregate analysis are Kyrgyzstan, Luxembourg, Malta, Panama, Paraguay, Senegal, Slovakia, Australia, and South Korea.

Figure 2.5: Marginal Effects of MR at Country-level



is countervailed in large industries. As shown in Figure 4, when the whole manufacturing sector employs beyond a 10% of the total population, the same institutional changes exert a positive effect in the economic performance of the manufacturing sector.

2.6 Conclusions

Electoral rules, which transform votes into seats in parliaments, are found to systematically affect the economic policy-making and economic institutions. The literature is still inconclusive on which electoral rule is more conducive to economic growth. Virtually all previous studies have assumed that electoral rules have homogeneous effects within countries. This paper argues that the ongoing debate over the economic effects of electoral systems is mired by the aggregate approach applied in extant works. We add to this literature by developing an industry disaggregated approach, in which we consider that electoral rules might have differential effects across industries operating within the same economies.

We study two hypotheses. First, we investigate whether electoral rules play a role in the economic performance of manufacturing industries. More proportional systems have been already found to favour broad interests, such as education and health programs, whereas plurality systems are more prone to cater to special interest groups. Trade and industrial policies are actually considered politically efficient ways to target key voters in existing research. We thus deem plausible a connexion between electoral rules and industry economic performance. Our second hypothesis is based on extant findings on how electoral rules interplay with industry geography to shape electoral incentives and therefore, alter the odds of an industry to gain political support. We surmise that the potential role of electoral rules in manufacturing industries - whether this is either growth-enhancing or growth-diminishing - might be contingent on the relative size of workers employed in an industry to total population.

We empirically test our two hypotheses on data from 61 manufacturing industries operating in 58 countries over 1990-2010. Our results associate majoritarian electoral rules to a growth-diminishing effect in annual growth rates of industries. Nevertheless, this effect hinges upon the ratio of employees in each industry to total population. In large industries, institutional changes towards plurality systems are associated with an increasing growth effect. These results are robust to a variety of sensitivity checks, such as alternative specifications and estimation techniques. Foremost, we find that higher levels of disproportionality in parliaments (Gallagher index) are associated with a negative effect in industry growth rates, which turns out to be positive in large industries. Consequently, one might consider that the negative effect of majoritarian systems might be driven by the relative higher degree of disproportionality.

Finally, we would like to strike a note of caution on the external validity of our results. As explained by Rickard (2018), the study of the economic consequences of electoral rules is challenged by causality issues, given the impossibility of controlling for unobservable factors that drive the selection of electoral systems. Keeping this challenge in mind, our goal was to inform new avenues of research by considering that electoral rules might have heterogeneous implications on the economic performance across sectors within the same economies. There are interesting paths in which this research could be expanded. A straightforward step would be to use disaggregated data on the economic performance of agriculture and services. More complex ways to expand our research would demand geolocation data of industries to map them into electoral districts, although that setting would reduce the country and time coverage provided in the current paper.

2.7 Appendix

Table A2.1: Sample Countries by Electoral System

MR	PR		MS
Australia	Albania (MS to PR, 2009)	Kyrgyzstan	Bolivia (PR to MS, 1997)
Canada	Argentina	Latvia	Bulgaria (PR to MS, 2009)
France	Austria	Luxembourg	Ecuador (PR to MS, 1998)
India	Belgium	Malta	Georgia
Malawi	Brazil	Moldova	Germany
Mauritius	Sri Lanka	Netherlands	Greece (PR to MS,2007)
Mongolia	Chile	Norway	Italy (PR to MS,1994)
Trinidad and Tobago	Colombia	Paraguay	Japan (MR to MS, 1996)
United Kingdom	Cyprus	Peru	South Korea
United States of America	Czech Republic	Portugal	Lithuania
	Denmark	Slovakia	Madagascar
	Estonia	Slovenia	Mexico
	Finland	Spain	Panama
	Indonesia	Sweden	Philippines (MR to MS,1998)
	Ireland	Macedonia (MR to PR,1998)	Romania (PR to MS,2008)
	Israel	Uruguay	Senegal

Table A2.2: Industries in the Sample

151 Processed meat,fish,fruit,vegetables,fats	273 Casting of metals
1520 Dairy products	281 Struct.metal products;tanks;steam generators
153 Grain mill products; starches; animal feeds	289 Other metal products; metal working services
154 Other food products	291 General purpose machinery
155 Beverages	292 Special purpose machinery
1600 Tobacco products	2930 Domestic appliances n.e.c.
171 Spinning, weaving and finishing of textiles	3000 Office, accounting and computing machinery
172 Other textiles	3110 Electric motors, generators and transformers
1730 Knitted and crocheted fabrics and articles	3120 Electricity distribution & control apparatus
1810 Wearing apparel, except fur apparel	3130 Insulated wire and cable
1820 Dressing & dyeing of fur; processing of fur	3140 Accumulators, primary cells and batteries
191 Tanning, dressing and processing of leather	3150 Lighting equipment and electric lamps
1920 Footwear	3190 Other electrical equipment n.e.c.
2010 Sawmilling and planing of wood	3210 Electronic valves, tubes, etc.
202 Products of wood, cork, straw, etc.	3220 TV/radio transmitters; line comm. apparatus
210 Paper and paper products	3230 TV and radio receivers and associated goods
221 Publishing	331 Medical, measuring, testing appliances, etc.
222 Printing and related service activities	3320 Optical instruments & photographic equipment
2230 Reproduction of recorded media	3330 Watches and clocks
2310 Coke oven products	3410 Motor vehicles
2320 Refined petroleum products	3420 Automobile bodies, trailers & semi-trailers
2330 Processing of nuclear fuel	3430 Parts/accessories for automobiles
241 Basic chemicals	351 Building and repairing of ships and boats
242 Other chemicals	3520 Railway/tramway locomotives & rolling stock
2430 Man-made fibres	3530 Aircraft and spacecraft
251 Rubber products	359 Transport equipment n.e.c.
2520 Plastic products	3610 Furniture
2610 Glass and glass products	369 Manufacturing n.e.c.
269 Non-metallic mineral products n.e.c.	3710 Recycling of metal waste and scrap
2710 Basic iron and steel	3720 Recycling of non-metal waste and scrap
2720 Basic precious and non-ferrous metals	

61 ISIC industries from INDSTAT from UNIDO (3 digit-level 2010, rev. 3)

Table A2.3: Data Sources

Variable	Description	Data Source
Growth	Annual growth rates at manufacturing industry-level	UNIDO
Manu. Employ	Employment in manufacturing sector to total population ratio	UNIDO & World Bank
Industry Employ	Industry employment to total population ratio.	UNIDO & World Bank
Industry Output Share	Industry output to manufacturing sector output ratio.	UNIDO
ln Industry Output	Natural logarithm of industry output.	UNIDO
Manu	Natural logarithm of manufacturing sector output.	UNIDO
Manu Growth	Annual growth rates of manufacturing sector output.	UNIDO
MR	Dichotomous variable that takes on the value 1 when a country is a majoritarian system, 0 otherwise.	Bormann and Golder (2013)
PR	Dichotomous variable that takes on the value 1 when a country is a proportional representation system, 0 otherwise.	Bormann and Golder (2013)
Mixed	Dichotomous variable that takes on the value 1 when a country is a mixed system, 0 otherwise.	Bormann and Golder (2013)
GDP *per capita*	Natural logarithm of gross domestic product divided by midyear population in current U.S. dollars.	World Bank
GDPpc Growth	Annual growth rate of GDP Per Capita.	World Bank
Human Capital	Total enrollment in secondary education as a percentage of the population of official secondary education age.	UNESCO, World Bank
Civil Liberties (CL)	Survey indicator based on freedom of expression and belief, associational and organizational rights, rule of law, and personal and individual rights, rescaled and ranging from 1 (lowest) to 7 (highest level of CL).	Freedom House
ln Population	Natural logarithm of total population.	World Bank (ver. April 2014)
Trade (% of GDP)	The sum of exports and imports of goods and services measured as a share of gross domestic product.	World Bank
Tariff on Manufacturing	Simple mean applied tariff is the unweighted average of effectively applied rates for manufacturing products subject to tariffs calculated for traded goods	World Bank
GI index	Gallagher Index compares vote share to seat share of parties in parliaments, a score of 0 would indicated a perfect proportional vote-seat relation.	Christopher Grandud database
ENEP	Effective number of electoral parties as defined by Taagepera (1997)	Bormann and Golder (2013)

Table A2.4: Alternative Measures of Electoral Rules and 5-yr Growth Rates

	(1) WG	(2) WG	(3) OLS	(4) WG
GI	-0.004**			
	(0.002)			
Industry Employ	-51.124***	-98.946*	-35.453***	-29.654
	(11.113)	(57.449)	(9.904)	(30.003)
GI * Industry Employ	2.757***			
	(0.493)			
Share VA	-5.053***	-4.575***	-4.898***	1.354
	(0.742)	(1.201)	(0.764)	(2.336)
Manu (ln)	-0.153***	0.012	-0.165***	0.491*
	(0.020)	(0.073)	(0.021)	(0.265)
GDP pc	0.319**	1.527**	0.393***	1.398
	(0.131)	(0.598)	(0.141)	(1.430)
Human Capital	0.168***	0.204***	0.144***	-1.288***
	(0.027)	(0.071)	(0.032)	(0.265)
Civil Liberties	0.002	-0.115***	-0.000	0.047
	(0.008)	(0.031)	(0.008)	(0.078)
Population (ln)	0.254**	0.217	0.206*	-1.121
	(0.110)	(0.360)	(0.122)	(1.377)
Trade	0.004***	0.003***	0.003***	-0.002
	(0.000)	(0.001)	(0.000)	(0.004)
Tariffs	-0.009***	0.011	-0.007***	-0.023
	(0.002)	(0.016)	(0.002)	(0.061)
RER	-0.015	0.062	-0.010	0.035
	(0.010)	(0.039)	(0.010)	(0.068)
Area (ln)	0.931*	5.375	0.706	-19.021***
	(0.520)	(4.321)	(0.561)	(4.329)
ENEP		-0.010		
		(0.014)		
ENEP * Industry Employ		12.206*		
		(6.225)		

MR			-0.202***	-2.011***
			(0.029)	(0.314)
MR * Industry Employ			67.430***	134.141**
			(9.398)	(60.829)
Constant	-12.183*	-69.483	-6.906	242.411***
	(7.015)	(53.869)	(6.339)	(59.327)
N	18033	4180	18110	9838
R^2	0.686	0.754	0.704	0.437
No. of Groups	2226.000	1719.000		1607.000
log-likelihood	-2808.455	671.612	-3144.482	-22927.612
Within R-squared	0.686	0.754		0.437
Between R-squared	0.005	0.000		0.011
Overall R-squared	0.053	0.002		0.010

Columns 1-3 use annual growth rates as dependent variable

Columns 4 uses 5-year growth rates as dependent variable

Clustered standard errors in parentheses (country-industry level)

* $p < .1$, ** $p < .05$, *** $p < .01$

Table A2.5: Majoritarian Rules and Manufacturing Sector Annual Growth Rates

	(1)	(2)	(3)
	WG	WG	WG
MR	-0.078***	-0.391***	-0.445***
	(0.026)	(0.102)	(0.131)
Manu Employ	-2.301**	-2.877***	-2.677***
	(0.865)	(1.000)	(0.697)
GDP pc	0.322	0.293	0.368
	(0.506)	(0.508)	(0.325)
MR * Manu Employ		3.967***	4.207**
		(1.371)	(1.716)
Human Capital			0.009
			(0.062)
Civil Liberties			0.004
			(0.012)
Popluation (ln)			0.057
			(0.308)
Trade			0.002*
			(0.001)
Tariffs			-0.004**
			(0.002)
RER			-0.006
			(0.030)
Area (ln)			1.947**
			(0.898)
Constant	0.034	0.098	-24.399
	(0.104)	(0.118)	(14.807)
N	471	471	367
R^2	0.948	0.949	0.963
No. of Groups	49.000	49.000	43.000
log-likelihood	456.264	458.315	418.430
Within R-squared	0.948	0.949	0.963
Between R-squared	0.696	0.490	0.007

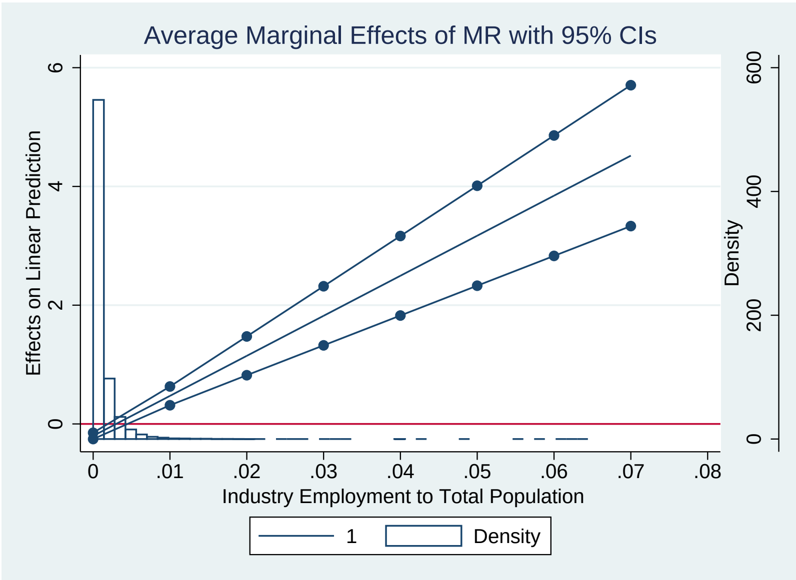
Overall R-squared	0.921	0.894	0.013

Dependent variable annual growth rates of total manufacturing sector

Clustered standard errors in parentheses (country-level)

* $p < .1$, ** $p < .05$, *** $p < .01$

Figure A2.1: Marginal Effects of MR



The graph expands Figure 2.1 by showing marginal effects at values of industry employment of the full sample.

Table A2.6: Average Marginal Effects of MR at Levels of Industry Employment

Industry Employment	dy/dx	robust s.e.	z	p-value
0	-.202	.0269	-7.50	0.000
0.01	.473	.081	5.87	0.000
0.02	1.147	.167	6.89	0.000
0.03	1.821	.254	7.17	0.000
0.04	2.496	.342	7.30	0.000
0.05	3.17	.43	7.38	0.000
0.06	3.844 6	.517	7.43	0.000
0.07	4.518 2	.605	7.46	0.000

Based on sample used in model estimated in Column 4 Table 2.2

Figure A2.2: Marginal Effects of Disproportionality

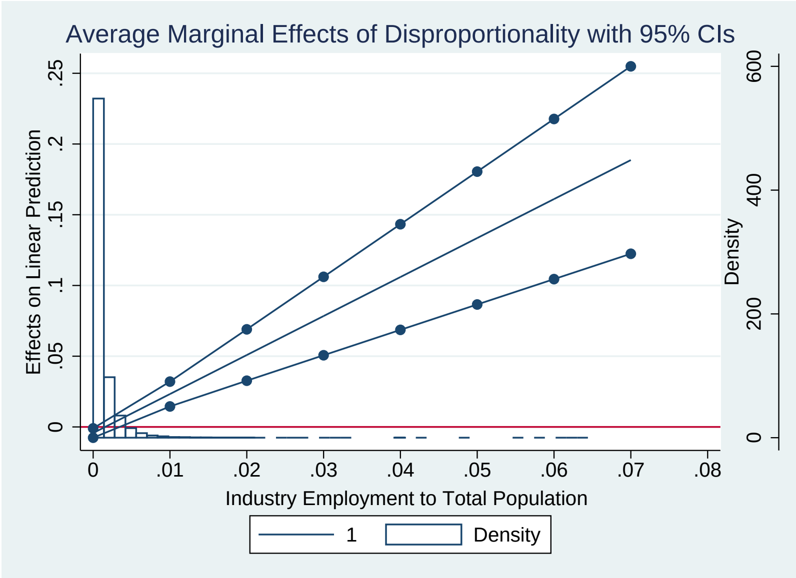


Table A2.7: Average Marginal Effects of Disproportionality at Levels of Industry Employment

Industry Employment	dy/dx	robust s.e.	z	p-value
0	-.004	.002	-2.55	0.011
0.01	.023	.004	5.19	0.000
0.02	.050	.009	5.49	0.000
0.03	.078	.014	5.54	0.000
0.04	.106	.019	5.56	0.000
0.05	.134	.024	5.57	0.000
0.06	.161	.029	5.58	0.000
0.07	.189	.034	5.58	0.000

Based on sample used in model estimated in Column 1, Table A2.4

Table A2.8: Average Marginal Effects of MR at Levels of Manufacturing Employment

Manufacturing Employment	dy/dx	robust s.e.	z	p-value
0	-.445	.131	-3.41	0.001
0.05	-.235	.05	-4.77	0.000
0.1	-.024	.05	-0.48	0.628
0.15	.186	.132	1.41	0.158

Based on sample used in model estimated in Table A2.5

3 — Electoral systems and income inequality: a tale of political equality

> "A key characteristic of a democracy is the continued responsiveness of the government to the preferences of its citizens, considered as political equals".
>
> Robert Dahl, 1973, pg. 1

3.1 Introduction

This paper looks at the distribution of political and economic power among citizens within countries. This research is motivated by the rising levels of income inequality, specifically in rich democracies, over the last decades. It is facilitated by the current availability of data on both income inequality and political equality across countries and time periods (Milanovic, 2000; Verba and Orren, 1985). Although scholars differ on how to define and measure economic inequality, they share a common concern about inequality which is intrinsically linked to social justice and fairness. Further, any discussion on the cause and consequences of inequality should, as stated in Bonica et al. (2013), include political and public policy considerations. In fact, the link between political institutions and income inequality is at the core of democratic theory and political economy (Przeworski, 2010).

At first glance, democratic regimes might be expected to be more likely to implement inequality-correcting policies and should thus be associated with lower levels of income inequality[1]. Against this prior, empirical evidence shows that democratic governments coexist quite blithely

[1] The workhorse model of democracy-inequality literature is provided in Meltzer and Richard (1981), which has been widely challenged both by theoretical and empirical scholarship (Benabou, 2000; Milanovic, 2000)

with rising levels of income inequality. The underlying arguments in the literature stress that societies are divided along multifaceted cleavages that go beyond economic distribution (Roemer, 2009; Scheve and Stasavage, 2017). Another reason underlying rising inequality in democracies is political capture by an elite through either *de jure* or *de facto* political institutions (Acemoglu et al., 2015). Yet empirical literature on democracy and inequality seems far from reaching a consensus[2].

One strand of political economy literature uses variation within democracies to study the inequality consequences of electoral systems, which are usually divided into majoritarian systems and proportional representation systems (Lijphart, 2012). Austen-Smith (2000) observes that proportional representation systems, usually characterized by more than two parties, exhibit higher tax rates and flatter income distribution than the typical two-party majoritarian electoral systems. Empirical research on these mechanisms tends to associate more proportional electoral systems with lower levels of within-country income inequality (Birchfield and Crepaz, 1998; Verardi, 2005). Nevertheless, the literature suggests a need for more complex specifications to give sound empirical leverage to the link between electoral systems and income inequality.

This paper argues that *de facto* distribution of political power might -at the very least- distort the impact of *de jure* political institutions (e.g. regime type and electoral systems) on inequality. The distribution of political power across socio-economic positions, i.e. political equality, refers to the extent to which members of a polity possess equal political power (Pemstein et al., 2015). Policy outcomes, and thus inequality, might crucially depend on the distribution of power (Acemoglu et al., 2015). By studying political equality we test whether democratic institutions fail to implement inequality-correcting policies due to political capture by an elite (e.g. economic elite).

Existing empirical analyses are silent about the role of political equality on income inequality, mainly due to the complexity of measuring the phenomenon (Verba and Orren, 1985; Bartels, 2017). This paper adds to the literature by employing a novel measure of political equality taken from the Varieties of Democracy (V-Dem) Database. Although they have similar roots, democracy -as a political regime type- and political equality are in fact two separate concepts. As I argue here, the difference between them stems from the *de jure* nature of the former and the *de facto* nature of the latter. Descriptively, the data on political equality employed here varies substantially across democracies. This suggests that not all democracies perfectly

[2]Empirical research associates democracy with either a negligible or increasing effects on income inequality (Dreher and Gaston, 2008; Scheve and Stasavage, 2009; Acemoglu et al., 2015)

represent individuals from all socio-economic positions, which is a recurrent claim in the field (Gilens and Page, 2014; Bartels, 2009; Houle, 2018).

The aim of this paper is to test whether the interplay between *de jure* political institutions (e.g. democracy and electoral systems) and the *de facto* distribution of political power affects within-country income inequality. More precisely, I surmise that the effect of electoral systems on income inequality hinges upon political equality. To estimate this relationship, I specify fixed-effects interactive models using a panel of 121 countries for the period from 1960 to 2007. The main results suggest that increasing political equality reduces income inequality. This effect is greater in majoritarian electoral systems than in proportional representation systems. The estimates do not associate political regimes and electoral systems with significant effects on inequality, although more proportional parliaments may reduce inequality in advanced economies.

The rest of the paper is structured as follows. Section 2 presents the hypothesis. Section 3 explains the data and empirical strategy. Section 4 shows the main findings and Section 5 checks the sensitivity of the results. Section 6 concludes.

3.2 Stylized facts and hypothesis

The prevailing wisdom among scholars entails strong stylized facts about the effects of electoral systems on the economy at large, and on redistribution and inequality in particular. This body of research speaks to the sensitivity of governments to cater to different groups in the electorate, which may in turn lead to different levels of income inequality. The features of electoral systems have been studied for instance on the basis of geographic concentration (Rickard, 2012a) and strength of lobbying activities (Naoi and Krauss, 2009). Other inequality effects of electoral systems have been established on the basis of trade-oriented economies (Kono, 2009), the political representation of minorities (Norris et al., 2004), and left *vs.* right leaning of governments (Iversen and Soskice, 2006). Overall, the evidence tends to show that proportional representation systems have greater redistribution and public spending than majoritarian systems (Persson and Tabellini, 2004b; Persson et al., 2007; Lizzeri and Persico, 2001). It follows that proportional systems should be associated with lower income inequality.

Verardi (2005) focuses on the effect of district magnitude of electoral systems on income inequality. Using data on 28 countries and a four-year time span, he finds that when the degree of proportionality increases, income inequality decreases. Along similar lines, Birchfield and Crepaz (1998) considers the larger number of effective parties under proportional representation than in majoritarian systems to study the link between electoral systems and income inequality. Using data on 18 countries at two points in time, they find that proportional representation systems (majoritarian systems) are associated with lower (higher) income inequality. Nonetheless, policy outcomes and inequality depend not only on *de jure* but also on *de factor* political institutions (Acemoglu et al., 2015). This argument is theoretically modelled by Acemoglu and Robinson (2008), who show that changes in *de jure* political institutions (e.g. electoral systems) create incentives for former or new elites to invest in *de facto* political power to offset those changes.

> *"De facto power is often essential for the determination of economic policies and the distribution of economic resources, but it is not allocated by institutions; rather, it is possessed by groups as a result of their wealth, weapons, or ability to solve the collective action problem. A change in political institutions that modifies the distribution of de jure power need not lead to a change in equilibrium economic institutions if it is associated with an offsetting change in the distribution of de facto political power (e.g., in the form of bribery, the capture of political parties, or use of paramilitaries)".* (Ibid., 2008: 268)

Here, I hypothesize that whatever effect changes between proportional and majoritarian systems may exert on income inequality, it must be contingent upon the distribution of political power. In a sense, the current paper may serve as an empirical test for the theoretical model of Acemoglu and Robinson. I estimate the joint effect of changes in electoral systems (as a *de jure* political institution) and political equality (as a *de facto* political institution) on within-country income inequality. The data coverage used and the complexity of the mechanism proposed here are intended to supplement previous approaches to examine the effects that electoral systems in particular, and political institutions at large, exert on income inequality.

3.3 Data and empirical analysis

I estimate combined cross-country time-series regressions using data for 121 countries over the period from 1960 to 2007. The dependent variable is within-country household gross income inequality, also known as market income inequality, which refers to income inequality before taxes and transfers. Gross income inequality is measured by the Gini coefficient taken from the version 5.1 of the Standardized World Income Inequality Database (SWIID). The Gini coefficients are provided in percentage terms, ranging theoretically from 0 (perfectly equal income distribution) to 100 (one household possesses all the income in the country). The SWIID methodology uses multiple imputations to extend the UNU-WIDER homogeneous inequality series for missing data (Solt, 2016).

The primary goal of the SWIID is to meet the needs of cross-national comparisons, enabling scholars to overcome the well-known limitations regarding country and time coverage, harmonization of definitions, and other shortcomings. The SWIID also provides the Gini net coefficient of income inequality (post-tax, post-transfer), and measures of absolute redistribution (market-income inequality minus net-income inequality) and relative redistribution (market-income inequality minus net-income inequality, divided by market-income inequality). The data on these alternative measures of inequality and redistribution are used as dependent variables in subsequent Sections to check the sensitivity of the main results.

The imputation model employed by Solt (2016) provides a substantial data coverage in terms of countries and time periods. However, it comes at the cost of potential bias and precisions issues (Jenkins, 2015). Hence, I check the external validity of the main results by using the World Bank All the Ginis Database (Milanovic, 2014) as an alternative data source on income inequality[3].

I propose the following interactive fixed-effects model to estimate the effects of political equality, electoral systems and the interaction between them on the distribution of income.

$$
\begin{aligned}
Y_{ct} &= \beta_0 + \beta_1 PolEq_{c,t-1} + \beta_2 PR_{c,t-1} + \beta_3 PolEq_{c,t-1} * PR_{c,t-1} + \alpha X_{c,t-1} + u_{ct} \\
u_{ct} &= \delta_c + \gamma_t + \epsilon_{ct} \\
c &= country; t = year
\end{aligned}
\tag{3.1}
$$

where the dependent variable Y_{ct} is gross Gini in logarithms, using SWIID unless otherwise stated, in country c in year t. The focal explanatory variables are political equality ($PolEq$) and proportional representation (PR) in year $t-1$. $X_{c,t-1}$ stands for a set of control variables in year $t-1$, and δ_c and γ_t are country and time fixed-effects respectively. All the models include clustered standard errors at country level to accurately account for heteroskedasticity and autocorrelation. Overall, this specification aims to correct previous research by controlling for country fixed-effects, since its omission might give false results due to omitted variable bias, as noted in Acemoglu et al. (2015). The data sources, sample of countries and summary statistics are relegated to Tables A3.1 and A3.2 in the Appendix.

[3] I also used the University of Texas Inequality Project (UTIP) data on household income inequality, which are not included here to save space but are available upon request.

A note of caution should be struck regarding reverse causality issues. Political institutions are able to profoundly shape the economy through policy platforms, but economic actors have a massive impact on the workings of political authority (Hacker and Pierson, 2010). To alleviate this concern, all the independent variables are one period lagged. Section 5.4 tackles the issue of reverse causality in detail.

3.3.1 Independent variables

Electoral systems

Electoral systems are measured by means of a dichotomous variable which is set to one for proportional representation systems (PR, hereafter) and zero otherwise (majoritarian or mixed systems), taken from Bormann and Golder (2013) database. During the period considered in the estimations (1960-2007), the countries in the database underwent 29 electoral changes, as shown in Table A3.4 in the Appendix.

Figure 3.1: Income Inequality by Electoral System

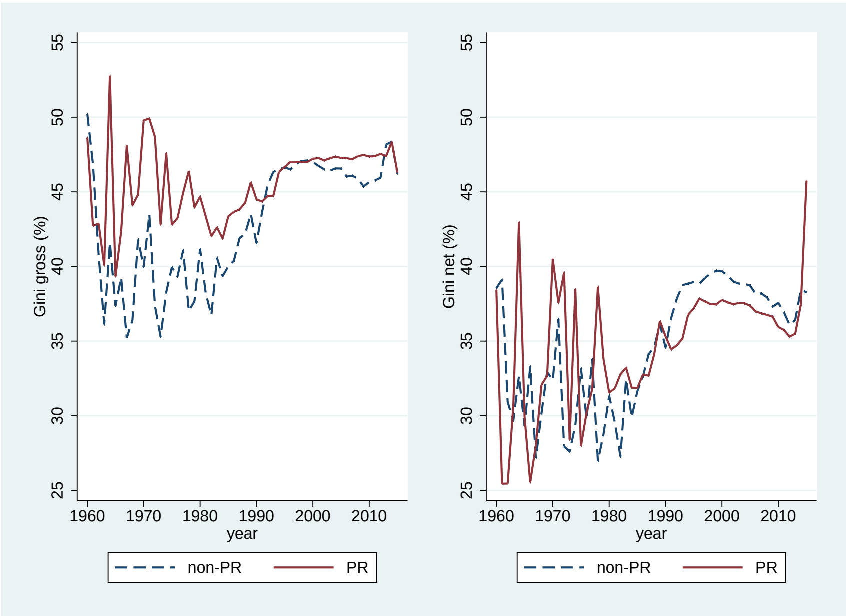


Figure 3.1 shows average gross and net Gini coefficients for PR and non-PR systems for 1960-2015. It shows that income inequality moves similarly under the two types of system. PR countries show slightly higher levels of gross income inequality, but lower levels of net income inequality than non-PR countries. The literature finds that the banking crisis may be an important driver of income inequality (De Haan and Sturm, 2017). Consequently, I restrict the data to the years prior to the Great Recession and the estimations use data for 1960-2007.

Political equality

The V-Dem project defines political equality as the extent to which political power is evenly distributed according to socio-economic groups of individuals[4]. As the V-Dem codebook states, the conceptualization of political equality is built on the real political power that a group of individuals wield on the basis of whether they a) actively participate in politics (by voting, etc. et al.); b) are involved in civil society organizations; c) secure representation in government; d) are able to set the political agenda; e) influence political decisions; and f) influence the implementation of those decisions (Pemstein et al., 2015).

Country experts are instructed to use a continuous scale from 0 to 4 to assign the distribution of political power among the citizenry based on different socio-economic groups. Starting from 0 (wealthy people enjoy a virtual monopoly on political power), 1 (wealthy people enjoy a dominant hold on political power), 2 (wealthy people have a very strong hold on political power), 3 (wealthy people have more political power than others), and 4 (wealthy people have no more political power than those whose economic status is average or poor). The observation with the lowest level of political equality is that for Ukraine in 2000 (0.094) and the highest is for Sweden in 1983 (3.799).

Figure 3.2: Political Equality and Income Inequality (2005)

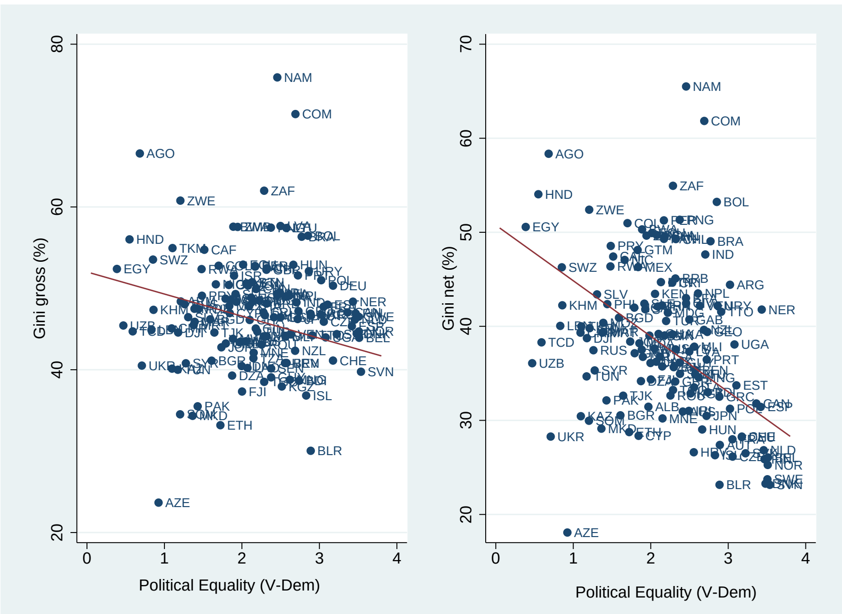


Figure 3.2 shows the measure of political equality and gross and net Gini coefficients of income inequality. In both cases, higher levels of political equality among socio-economic

[4]For the purposes of this research, I focus on socio-economic groups. The V-Dem dataset also provides data on the political equality of groups of individuals according to social groups (e.g. caste, ethnicity, language, religion), gender and sexual orientation.

groups are related to lower levels of income inequality. The appendix also includes scatter plots on political equality and redistribution (Figure A3.1).

Control variables

X_{ct} in Equation (3.1) includes a set of control variables. The specification controls for a political regime dummy for democratic regimes in country c in period t taken from Boix et al. (2013) (BMR hereafter). The inclusion of this variable is crucial to disentangle the effect of political equality from the type of political regime. A country is considered democratic if it satisfies conditions for both contestation i) "The executive is directly or indirectly elected in popular elections and is responsible either directly to voters or to a legislature"; ii) "the legislature (or the executive if elected directly) is chosen in free and fair elections", and participation iii) "a majority of adult men has the right to vote" (Boix et al., 2013). With this definition at hand, the difference between democracy and political equality is straightforward.

Figure 3.3: Political Equality by Political Regime

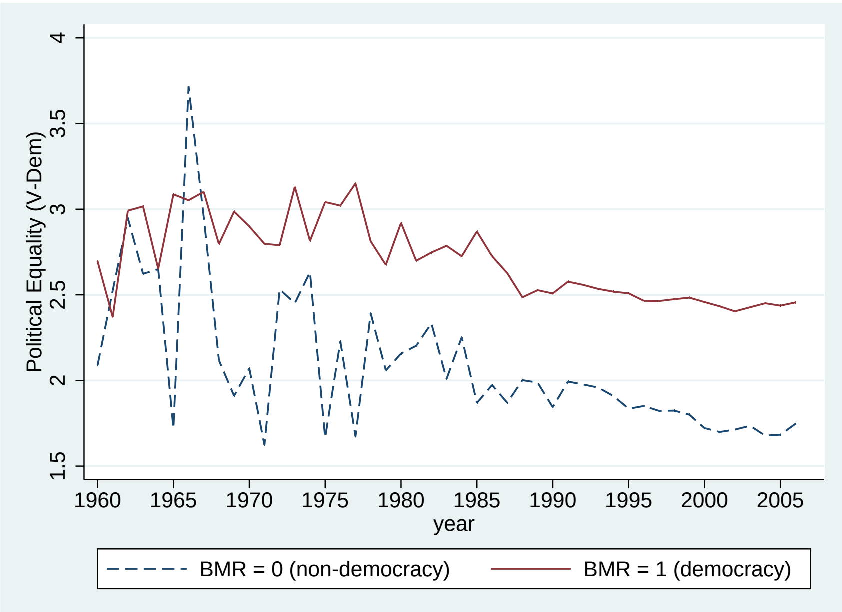


Figure 3.3 shows that despite the generally higher levels of political equality under democracies (BMR equals 1), both democratic and non-democratic countries show similar trends in political equality from 1960 to 2007. It is worth noting that the minimum figure for political equality in non-democracies is higher than in democracies, and that the variability in political equality is greater for democracies than for non-democracies (see Table A3.6 in the Appendix). As highlighted in Acemoglu et al. (2015), the duration of democratic history is neither tackled nor recognized in the extant literature. Although it lies beyond the scope of the current paper, the link between historical democratic experience and income inequality seems an important

feature in isolating the inequality effect of political equality. Thus, in subsequent models I include the number of consecutive years of democratic experience of countries (Age of democracy), also taken from the Boix et al. (2013) database.

Concern must be shown for collinearity issues arising from the relationship between the political institutional variables included in the model. Table A3.5 in the Appendix shows pair-wise correlations between political equality, regime type (BMR), electoral systems (PR), and duration of democratic experience. None of these correlations posits a problem in the estimations and they further corroborate the split between the concept of democracy and political equality.

The models include the logarithms of level and squared of gross domestic product (GDP) per capita. The so-called inverted-U shaped relationship between economic development and inequality formalized by Kuznets (1955) states that income inequality first increases in the course of economic development, then peaks, and then decreases. However, there is growing evidence to support a U-shape rather than an inverted U-shape relationship between economic development and inequality (Dreher and Gaston, 2008), suggesting that inequality is high for low levels of development, decreases in the course of economic development and increases again in affluent countries. Indeed, Lessmann and Seidel (2017) explore the non-linearity of the GDP-inequality linkage in the context of regional inequality and find a cubic function by which GDP might have an N-shaped effect on inequality. This possibility is also considered in the set of regressions below.

I follow standard literature on income inequality to control for the educational attainment of the population, the dependency ratio, the inflation rate and trade openness. Education is measured by the average number of years of education of the population over 15 year-old, and the dependency ratio is measured by the ratio of people over 65 years-old to the total population. Empirical evidence suggests that increasing human capital is associated with reducing income distribution (Gregorio and Lee, 2002). By contrast, a larger proportion of elderly people is associated with an inequality-enhancing effect (Deaton and Paxson, 1998). For inflation, Bulíř (2001) finds a non-linear effect of inflation on income inequality by which reductions from hyperinflation tend to reduce inequality, while very low levels of inflation are associated with a negligible or increasing effect in income inequality. For trade openness, which is included in the models as exports and imports as proportion of GDP, the literature is inconclusive. Indeed, economic globalization might have different effects on developed and developing countries (Dreher and Gaston, 2008).

I seek to supplement previous research on the effect of electoral institutions on income inequality by controlling for additional financial globalization features. The final set of controls refers to the growing evidence that different components of financial globalization might have opposite effects on income inequality (Asteriou et al., 2014). I explore here whether the results are affected by the inclusion of composite measures of economic globalization (using the KOF index of economic globalization), or different components of economic globalization, such as stock market capitalization and foreign direct investment (FDI), as a percentage of GDP in both cases.

3.4 Results

Table 3.1 shows the estimates of Equation (3.1) using the annual gross Gini coefficient as the dependent variable. Generally, the results suggest that increasing political equality, the age of democracy, and financial indicators are determinants of income inequality.

Column 1 of Table 3.1 shows estimates of a model on PR and political equality without its interaction and a subset of controls that do not consider financial indicators. Political equality is always associated with a statistically significant coefficient, but PR is not associated with a significant effect on income inequality. GDP per capita in levels is generally associated with an inequality-decreasing effect, as in Dreher and Gaston (2008). However, the squared GDP per capita is not associated with a significant effect. These results remain when the KOF index of economic globalization (Column 2) and decomposed indicators of financial internationalization are considered (Column 3). The estimates suggest that the stock market is significant, so the subsequent models include that covariate. The direction of this finding points to an inequality-reducing effect of the stock market, as found in Asteriou et al. (2014). As regards other control variables, most of the models estimated point to a reducing-effect of educational attainment and an increasing effect of the dependency ratio on income inequality. Both associations are consistent with previous studies. Inflation is associated with an increasing but small effect on inequality.

Column 4 of Table 3.1 includes the interaction between PR and political equality. The constitutive term of political equality remains statistically significant and PR remains not significant. However, the interaction is significant, meaning that the effect exerted by political equality on income inequality depends on the electoral system used in each country. The positive sign of the interaction means that the inequality-reducing effect associated with political equality is lower when countries are PR. Note that BMR is never associated with a significant role in inequality. Consistently with the model by Acemoglu and Robinson (2008), *de facto* distribution of power has a stronger effect on inequality than changes in *de jure* political institutions. Indeed, based on the results here, changes in electoral institutions (PR and non-PR) are not associated with a significant effect on income inequality. To the contrary, political equality is robustly associated with an inequality-diminishing effect.

Table 3.1: Baseline and Preferred Models

Dependent variable: SWIID gross Gini (log)						
	(1)	(2)	(3)	(4)	(5)	(6)
L.Political Equality	-0.045**	-0.036*	-0.039**	-0.070***	-0.072***	-0.071***
	(0.021)	(0.019)	(0.015)	(0.017)	(0.017)	(0.018)
L.PR	0.032	0.035	0.037	-0.060	-0.056	-0.062
	(0.025)	(0.027)	(0.027)	(0.045)	(0.045)	(0.046)
L.Interaction				0.047**	0.044**	0.048**
				(0.019)	(0.020)	(0.020)
L.GDPpc (log)	-0.360*	-0.372	-0.211	-0.214	-0.209	5.535**
	(0.208)	(0.234)	(0.388)	(0.384)	(0.375)	(2.773)
L.Squared GDPpc (log)	0.017	0.018	0.014	0.015	0.014	-0.632**
	(0.012)	(0.014)	(0.021)	(0.021)	(0.020)	(0.315)
L.Cubic GDPpc (log)						0.024**
						(0.012)
L.BMR	-0.011	-0.012	-0.012	-0.019		
	(0.019)	(0.020)	(0.017)	(0.016)		
L.Age of democracy					0.000***	0.000**
					(0.000)	(0.000)
L.Education	-0.010	-0.009	-0.056***	-0.057***	-0.057***	-0.049***
	(0.025)	(0.024)	(0.017)	(0.018)	(0.017)	(0.018)
L.Dependency ratio	0.019***	0.020***	0.014*	0.016**	0.016**	0.018**
	(0.007)	(0.007)	(0.008)	(0.008)	(0.008)	(0.007)
L.Inflation	0.000	0.000*	0.000**	0.000**	0.000**	0.000*
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
L.Trade	0.000	-0.000	-0.001	-0.001	-0.001	-0.000

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Table 3.1: Baseline and Preferred Models

Dependent variable: SWIID gross Gini (log)						
	(1)	(2)	(3)	(4)	(5)	(6)
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
L.KOFecon		0.001				
		(0.001)				
L.Stock market			-0.000***	-0.000***	-0.000***	-0.000***
			(0.000)	(0.000)	(0.000)	(0.000)
L.FDI			0.000	0.000	0.000	0.000
			(0.001)	(0.001)	(0.001)	(0.001)
Constant	5.608***	5.545***	4.805**	4.828***	4.810***	-12.180
	(0.894)	(0.992)	(1.828)	(1.806)	(1.757)	(8.124)
No. of Obs.	2099	2039	1099	1099	1102	1102
No. of Groups	121.000	121.000	75.000	75.000	76.000	76.000
log-likelihood	2759.993	2715.767	1786.341	1796.589	1805.094	1812.373
Within R-squared	0.300	0.297	0.501	0.510	0.512	0.518

Standard errors in parentheses

* $p < .1$, ** $p < .05$, *** $p < .01$

* $p < .1$, ** $p < .05$, *** $p < .01$

Country-level clustered standard errors in parentheses

Within-group estimates, year fixed-effects included but not reported.

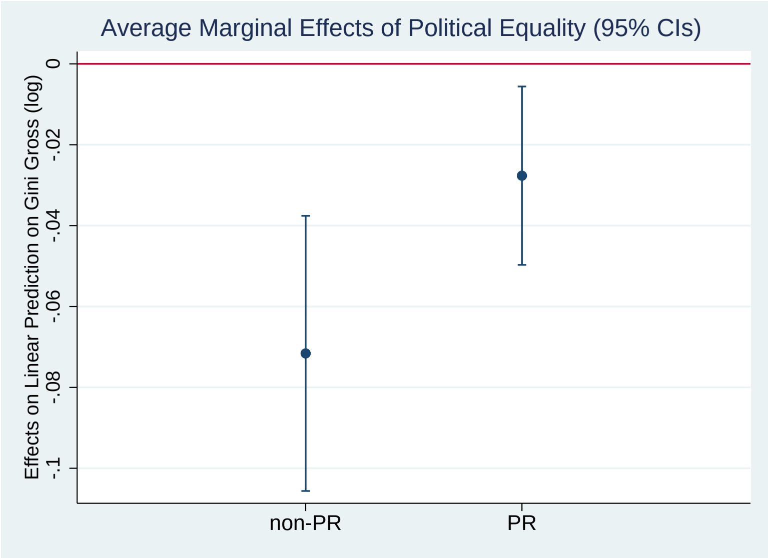
$Interaction_{ct}$ refers to the joint effect of Political Equality and Proportional Representation.

The preferred model is estimated in Column 5 of Table 3.1, which controls for the democratic experience rather than the political regime index (BMR). The political regime dummy was not associated with a significant coefficient, but the age of democracy is associated with a positive and significant effect on income inequality. Therefore, this results suggests that the cumulative democratic experience has an inequality-increasing effect.

The inequality-increasing effect associated with greater democratic experience can be interpreted along the lines of the so-called sclerotic hypothesis of Olson (1982). Scholars working in democracy-growth literature find a negative impact of the longer democratic experience on economic growth rates. It is suggested that democratising countries are likely to pursue growth-enhancing reforms in the short-run but may abandon them with the passage of time

(Olson, 1982; Przeworski, 1991). Applying the sclerotic hypothesis to the context of income inequality, early stages of the democratization process may have an economic equalization effect that then vanishes over time, resulting in a cumulative negative effect of democratic experience on within-country income inequality.

Figure 3.4: Marginal Inequality Effects of Political Equality



The point estimates in Column 5 of Table 3.1 imply that a unit increase in political equality last year decreases the gross Gini coefficient at the current year by about 7.2% under non-PR electoral systems. Figure 3.4 shows more clearly the marginal effects of a unit increase in political equality conditional upon each type of electoral system. In both cases more political equality is associated with a reducing effect in income inequality, but it is smaller reduced under PR systems. Under PR systems, one additional unit in the political equality score is associated with a reducing income inequality of about 2.8%.

Column 6 of Table 3.1 controls for the cubic function of GDP per capita to study the N-Shape relationship between economic development and income inequality. The estimates seem to provide leverage for the findings in Lessmann and Seidel (2017) in the context of regional inequality. However, the coefficient associated with GDP per capita in levels is remarkably large, so I do not include the N-shape conjecture in subsequent models. Nevertheless, the results for the core variables of this research remain unaltered.

3.5 Sensitivity checks

This Section follows in the footsteps of the sensitivity checks usually conducted in the existing literature on income inequality. I first use alternative data sources, measures of income inequality and redistribution. Second, I split the sample of countries into OECD and non-OECD countries. Third, I explore whether social or political globalization and features of voter turnout alter the main findings of the current research. Finally, I check the issue of reverse causality. Overall, the finding that political equality has a reducing effect on income inequality is consistent throughout the empirical analyses conducted in this paper.

3.5.1 Alternative data sources and measures of inequality

Columns 1 and 2 of Table 3.2 use data on income inequality taken from the All the Ginis database. Column 1 uses the logarithm of gross Gini coefficient as the dependent variable while Column 2 uses the logarithm of net Gini coefficient. The results associate both political equality and changes towards PR systems with reducing effects on income inequality, while the interaction between them remains significant and positive. However, it should be noted that the number of countries included in All the Ginis database, and thus the number of observations in these regressions is remarkably lower than when the SWIID is used.

Column 3 (Table 3.2) uses the logarithm of net Gini coefficients collected from SWIID as the dependent variable. In this case political equality is associated with a significant role in reducing inequality, but PR and the interaction between them are not significant. Columns 4 and 5 further explore the workings of political equality and redistribution by using as dependent variables the relative and absolute redistribution measures, respectively. *De facto* distribution of political power is associated with lower redistribution at 0.1 and 0.05 levels of significance. However, the interaction between political equality and PR is significant at the 0.05 level only for the case of relative redistribution, suggesting that increasing political equality enhances redistribution provided that the country has a PR system. As for the control variables, the U-shape function of GDP per capita seems to apply in redistribution, while the dependency ratio increases redistribution in both relative and absolute terms. Ultimately, the alternative results provide some empirical clues that political equality might be at the heart of both redistribution and income inequality in electoral democracies.

Table 3.2: Alternative Data Sources and Measures

Dependent variable: Alternative inequality or redistribution measures					
	WIDER		SWIID		
	(1)	(2)	(3)	(4)	(5)
	gross Gini	net Gini	net Gini	Rel. Redis.	Abs. Redis.
L.Political Equality	-0.137***	-0.158***	-0.045***	-1.624*	-1.719**
	(0.045)	(0.053)	(0.015)	(0.881)	(0.805)
L.PR	-0.385**	-0.468**	-0.045	-5.668	-2.205
	(0.147)	(0.186)	(0.045)	(4.900)	(3.685)
L.Interaction	0.145**	0.177**	0.021	3.340**	1.789
	(0.054)	(0.068)	(0.019)	(1.596)	(1.216)
L.GDPpc (log)	1.513**	0.772	0.238	-49.253**	-27.761**
	(0.719)	(1.021)	(0.341)	(21.185)	(13.085)
L.Squared GDPpc (log)	-0.070*	-0.033	-0.013	2.745**	1.549**
	(0.039)	(0.055)	(0.018)	(1.170)	(0.721)
L.Age of democracy	0.001***	0.001***	0.000***	-0.007	-0.001
	(0.000)	(0.000)	(0.000)	(0.005)	(0.003)
L.Education	0.070**	0.055*	-0.044**	-0.813	-0.822
	(0.028)	(0.030)	(0.018)	(1.181)	(0.721)
L.Dependency ratio	0.019*	0.020*	0.002	1.230***	0.622***
	(0.010)	(0.011)	(0.005)	(0.409)	(0.210)
L.Inflation	0.000*	0.000**	0.000	-0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.001)	(0.001)
L.Trade	0.001	0.000	-0.000	-0.022	-0.012
	(0.001)	(0.001)	(0.000)	(0.016)	(0.011)
L.Stock market	0.001***	0.000*	-0.000	-0.024***	-0.014***
	(0.000)	(0.000)	(0.000)	(0.008)	(0.004)
L.FDI	-0.000	0.000	0.001	-0.041	-0.013
	(0.001)	(0.001)	(0.001)	(0.053)	(0.034)
Constant	-4.738	-0.914	2.707*	241.563**	135.927**
	(3.234)	(4.680)	(1.576)	(94.603)	(59.173)

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Table 3.2: Alternative Data Sources and Measures

Dependent variable: Alternative inequality or redistribution measures					
	WIDER		SWIID		
	(1)	(2)	(3)	(4)	(5)
	gross Gini	net Gini	net Gini	Rel. Redis.	Abs. Redis.
No. of Obs.	353	386	1102	849	849
No. of Groups	46.000	52.000	76.000	51.000	51.000
log-likelihood	438.624	464.092	1878.907	-2035.022	-1568.453
Within R-squared	0.259	0.211	0.383	0.237	0.398

* $p < .1$, ** $p < .05$, *** $p < .01$

Country-level clustered standard errors in parentheses

Within-group estimates, year fixed-effects included but not reported.

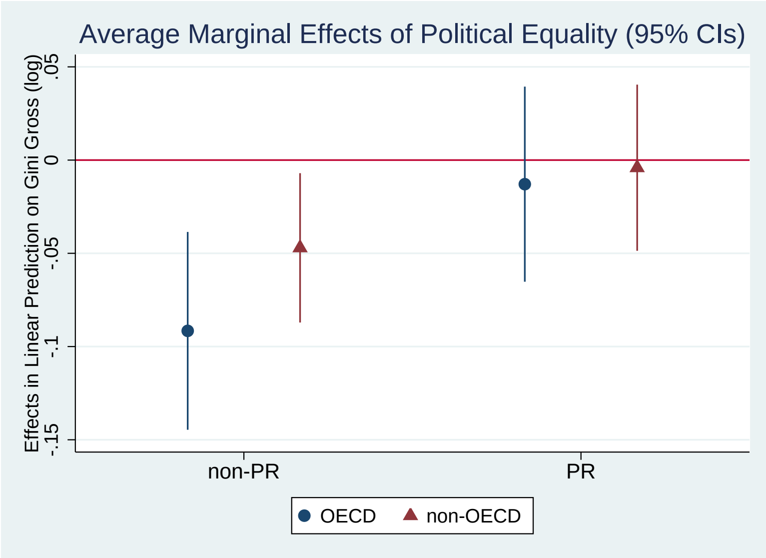
$Interaction_{ct}$ refers to the joint effect of Political Equality and Proportional Representation.

3.5.2 OECD versus non-OECD economies

Table 3.3 provides further sensitivity checks on the main results of the paper. Previous research has observed differences in the workings of the democracy-inequality between OECD and non-OECD countries, with the link being found to be stronger in OECD countries (Dreher and Gaston, 2008). Indeed, my results might serve to clarify this previous evidence.

Columns 1 and 2 (Table 3.3) use OECD and non-OECD countries separately to run the model in Equation (3.1). I focus on the results for the marginal effects of political equality under PR and non-PR separately for the two sub-samples, which are shown in Figure 3.5. The impact of increasing political equality in depressing income inequality seems to be stronger in OECD countries. Consistently with my previous results, the pro-income-equality effect of political equality is lower under PR. The point estimates suggest that in OECD countries increasing a one unit increase in political equality in the preceding year has an impact of -9.1% on income inequality in the current year under non-PR and of -8.1% under PR systems. For non-OECD countries, the effect of political equality on income inequality is lower: -4.7% under non-PR and of -0.4% under PR systems.

Figure 3.5: Estimates using OECD and non-OECD countries



Note that using the OECD sub-sample, the estimates associate both political equality and PR with a significant, negative effect on income inequality. This suggests that electoral systems play a role in advanced economies. In the case of non-OECD countries, political equality is associated with a significant effect but the impact of PR is not significant. In both country subsets, the interaction between political equality and electoral systems is significant. The results confirm again that interplay between *de jure* and *de facto* political institutions may be an important determinant of within-country income inequality. Furthermore, the split between OECD and non-OECD countries may show that *de jure* institutions work differently depending on the level of economic development of countries. However, the analysis of this triple interplay goes beyond the scope of this paper.

In both sub-samples, increasing democratic experience is associated with increasing levels of income inequality, which provides further leverage for Olson's sclerotic hypothesis applied to the democracy-inequality link. Nonetheless, the OECD and non-OECD sub-sample show differences in the estimates of other control variables. Education is not associated with a significant equalization effect in advanced economies, which might be driven by the homogeneity of educational attainment across OECD countries. In the non-OECD sub-sample, education is associated with reducing income inequality. Similarly, the proportion of elderly people seems to increase inequality in advanced economies but not in non-OECD countries. This may be related to population ageing in the former group of countries.

Table 3.3: Sensitivity Checks

Dependent variable: Annual or 5-yr mean SWIID gross Gini (log)								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	OECD	non-OECD	KOFsoc	KOFpol	Turnout	Non-mand		5-yr mean
L.Political Equality	-0.092***	-0.047**	-0.071***	-0.072***	-0.069***	-0.074***		
	(0.027)	(0.020)	(0.017)	(0.017)	(0.018)	(0.017)		
L5.Political Equality							-0.034**	-0.050**
							(0.016)	(0.020)
L.PR	-0.144**	-0.045	-0.058	-0.056	-0.066	-0.059		
	(0.069)	(0.043)	(0.047)	(0.046)	(0.046)	(0.044)		
L5.PR							0.006	-0.032
							(0.049)	(0.050)
L.Interaction	0.079**	0.043*	0.044**	0.045**	0.048**	0.048**		
	(0.032)	(0.025)	(0.020)	(0.019)	(0.020)	(0.019)		
L5.Interaction							0.009	0.021
							(0.018)	(0.020)
L.GDPpc (log)	-0.356	-0.374	-0.149	-0.190	-0.116	-0.174		
L5.GDPpc (log)							-0.722*	-0.656*
							(0.408)	(0.374)
	(1.187)	(0.871)	(0.431)	(0.381)	(0.359)	(0.343)		

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Table 3.3: Sensitivity Checks

Dependent variable: Annual or 5-yr mean SWIID gross Gini (log)								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	OECD	non-OECD	KOFsoc	KOFpol	Turnout	Non-mand		5-yr mean
L.Squared GDPpc (log)	0.018	0.027	0.011	0.013	0.009	0.012		
	(0.062)	(0.052)	(0.023)	(0.020)	(0.020)	(0.019)		
L5.Squared GDPpc (log)							0.044*	0.041*
							(0.022)	(0.021)
L.Age of democracy	0.000**	0.002**	0.000***	0.000***	0.000***	0.000***		
	(0.000)	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)		
L5.Age of democracy							0.000	-0.000
							(0.000)	(0.000)
L.Education	-0.032	-0.069***	-0.056***	-0.055***	-0.056***	-0.058***		
	(0.034)	(0.022)	(0.018)	(0.018)	(0.017)	(0.018)		
L5.Education							-0.039**	-0.035*
							(0.017)	(0.019)
L.Dependency ratio	0.017**	-0.015	0.016**	0.016**	0.016**	0.015*		
	(0.007)	(0.018)	(0.008)	(0.008)	(0.008)	(0.008)		
L5.Dependency ratio							0.013**	0.014**
							(0.006)	(0.006)

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Table 3.3: Sensitivity Checks

Dependent variable: Annual or 5-yr mean SWIID gross Gini (log)								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	OECD	non-OECD	KOFsoc	KOFpol	Turnout	Non-mand		5-yr mean
L.Inflation	0.001	0.000	0.000**	0.000***	0.000***	0.000**		
	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)		
L5.Inflation							0.000	0.000*
							(0.000)	(0.000)
L.Trade	-0.001	0.000	-0.001	-0.000	-0.001	-0.000		
	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)		
L5.Trade							-0.001*	-0.001**
							(0.000)	(0.000)
L.Stock market	-0.000***	-0.000	-0.000***	-0.000***	-0.000***	-0.000***		
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)		
L5.Stock market							-0.000**	-0.000**
							(0.000)	(0.000)
L.FDI	0.000	0.003	0.000	0.000	0.000	0.000		
	(0.001)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)		
L5.FDI							0.000	-0.000
							(0.001)	(0.002)

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Table 3.3: Sensitivity Checks

Dependent variable: Annual or 5-yr mean SWIID gross Gini (log)								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	OECD	non-OECD	KOFsoc	KOFpol	Turnout	Non-mand		5-yr mean
L.KOFsoc			-0.001					
			(0.002)					
L.KOFpol				-0.001				
				(0.001)				
L.Turnout					-0.001			
					(0.001)			
L.Non-compulsory voting						0.018		
						(0.034)		
Constant	5.679	5.348	4.563**	4.736**	4.428***	4.634***	6.956***	6.616***
	(5.726)	(3.722)	(1.945)	(1.798)	(1.667)	(1.596)	(1.850)	(1.671)
N	629	468	1097	1097	1093	1102	1089	302
R^2	0.600	0.337	0.512	0.512	0.510	0.512	0.460	0.474
No. of Groups	34.000	41.000	76.000	76.000	76.000	76.000	75.000	76.000
log-likelihood	983.123	882.837	1796.795	1796.835	1790.821	1805.830	1909.092	529.086
Within R-squared	0.600	0.337	0.512	0.512	0.510	0.512	0.460	0.474

* $p < .1$, ** $p < .05$, *** $p < .01$

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Table 3.3: Sensitivity Checks

Dependent variable: Annual or 5-yr mean SWIID gross Gini (log)								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	OECD	non-OECD	KOFsoc	KOFpol	Turnout	Non-mand		5-yr mean

Country-level clustered standard errors in parentheses

Within-group estimates, year fixed-effects included but not reported.

$Interaction_{ct}$ refers to the joint effect of Political Equality and Proportional Representation.

Column 7 employs the fifth lag of independent variables.

Column 8 employs 5-yr averages of all variables in non-overlapping periods 1980-2010.

3.5.3 Voter turnout, social and political globalization

Columns 3-6 in Table 3.3 expand the set of controls. I first check whether my results hold after including the KOF index of social (Column 3) and political globalization (Column 4). As suggested in Bergh and Nilsson (2010), a purely economic perspective on globalization might be too narrow in analysing distributional effects across countries. They find significant effects of social globalization on net Gini coefficients using SWIID in a panel of 80 countries for 1970-2005. Based on the estimates presented here, none of these covariates is associated with a significant impact on income inequality. Importantly, the main results associated with political equality and its interaction with PR remain the same.

The relationship between inequality and electoral turnout seems to differ across countries. Less developed and highly unequal societies are associated with higher turnouts, while more developed countries are associated with lower turnouts (Stokes et al., 2013). The mechanisms behind political participation and inequality might be not fully captured by the measure of political equality. Therefore, Columns 5-6 include respectively voter turnout, taken from Vanhanen and Lundell (2014) and non mandatory voting, taken from the V-Dem database. The results fail to associate turnout features with a significant impact on income inequality, but the main results of the paper remain unaltered.

3.5.4 Causality issues

The final step of the sensitivity check is to take further issue on reverse causality. Following Acemoglu et al. (2015), Column 7 in Table 3.3 shows estimates of Equation (3.1) using the fifth lag of the independent variables rather than one year lag. Notwithstanding that the effect of political equality remains, its interaction with PR is not significantly associated with an income inequality effect. Similar results are found when 5-year averages are used for all variables in non-overlapping periods between 1980 and 2010, as proceed in Dreher and Gaston (2008). These further checks suggest that *de facto* political institutions -such as the distribution of political power- might be a crucial determinant of within-country income inequality, whereas *de jure* political institutions might have a minor impact or none at all.

3.6 Conclusions

The starting point of this paper is the observation of rising income inequality in established democracies. In theory, democratic governments should be able to correct for rising inequality through the processes of enfranchisement and political competition. In practice, democracy and income inequality have coexisted without undue concern over the last few decades. Indeed, the literature is still inconclusive on the final effect of political institutions on income inequality. This paper suggests that *de jure* political institutions such as political regimes (democracy *vs.* autocracy) and electoral systems (majoritarian *vs.* proportional systems) play a minor role compared to the *de facto* distribution of political power.

Earlier studies associate more proportional systems with lower levels of income inequality. However, I draw on the theoretical model in Acemoglu and Robinson (2008) to argue that changes towards supposedly pro-equality *de jure* political institutions might be offset if political power is not evenly distributed among the socio-economic groups that make up the electorate. In this paper I show that political equality plays a stronger role than changes in electoral systems, which might serve as an empirical test of Acemoglu and Robinson's theoretical model. I use the SWIID data on income inequality for a panel data of 121 countries for 1960-2007. I link this data with a measure of political equality taken from the V-Dem database, along with information on electoral systems and political regime type, and other inequality drivers already proposed in the standard literature. My main findings associate political equality with a reducing effect on income inequality. This effect is found to hinge upon electoral systems, which means that political equality tends to exert a stronger effect under non proportional representation systems than in proportional systems. In any case, the impact of greater political equality is associated everywhere with an inequality-diminishing effect. The estimates fail to associate political regime types *per se* with a significant impact on income inequality, although electoral systems are associated with some explanatory power over income inequality in OECD countries.

This paper finds a robust partial and negative correlation between political equality and income inequality that partly depends on the electoral system. Notwithstanding that these results have a tentative causal interpretation under the usual assumptions of fixed-effects panel data models, I cannot deny the possibility of omitted factors driving both political and economic inequality. Likewise, a reverse causation from income inequality to political equality and electoral systems cannot be ruled out (Acemoglu et al., 2015; Scheve and Stasavage, 2017).

Finally, the natural next step to extend this research is to consider whether political equality among social groups, gender and sexual orientations (rather than among socio-economic groups) also plays a role in the within-country income distribution. Additionally, it would be interesting to consider other *de jure* political institutions rather than electoral systems.

3.7 Appendix

Table A3.1: Summary Statistics

Variable	Mean	Std. Dev.	Min.	Max.	N
Gross Gini (SWIID)	45.794	7.857	18.526	76.888	3532
Gross Gini (WIDER)	36.916	10.76	15.9	63.66	994
Net Gini (SWIID)	37.211	9.471	14.76	67.212	3532
Net Gini (WIDER)	37.067	10.183	15.9	63.66	1167
Absolute Redistribution	10.831	7.042	-5.294	26.89	1775
Relative Redistribution	23.686	15.192	-13.558	57.487	1775
Political Equality	2.293	0.828	0.05	3.8	3532
PR	0.427	0.495	0	1	3782
GDPpc (log)	8.585	1.056	6.038	10.53	2810
BMR	0.609	0.488	0	1	2780
Age of Democracy	41.559	44.98	1	208	2960
Education	7.182	3.049	0.08	13.482	3447
Dependency Ratio	6.426	4.355	1.05	23.159	7962
Inflation	49.195	553.277	-13.226	24410.98	3091
Trade	71.678	47.851	0.02	504.88	6408
Stock Market	24.071	40.549	0	320.992	1883
FDI	2.968	8.113	-82.89	252.31	5325
KOFecon	48.69	17.092	10.22	93.59	6075
KOFsoc	45.798	20.832	6.73	90.73	6196
KOFpol	55.887	22.743	3.13	99.540	6196
Turnout	37.708	19.076	0	70	3254
Non-compulsory Voting	0.799	0.401	0	1	3254

Countries in the sample

Albania, Algeria, Argentina, Armenia, Australia, Austria, Azerbaijan, Bangladesh, Belarus, Belgium, Benin, Bolivia, Botswana, Brazil, Bulgaria, Burkina Faso, Burundi, Cambodia, Cameroon, Canada, Central African Republic, Chad, Chile, Colombia, Comoros, Costa Rica, Cote d'Ivoire, Croatia, Cyprus, Czech Republic, Denmark, Dominican Republic, Ecuador, Egypt Arab Rep., El Salvador, Estonia, Fiji, Finland, France, Gambia The, Georgia, Germany, Ghana, Greece, Guatemala, Guinea, Guinea-Bissau, Guyana, Haiti, Honduras, Hungary, India, Indonesia, Iran Islamic Rep. Ireland, Israel, Italy, Jamaica, Japan, Jordan, Kazakhstan, Kenya, Kyrgyz Republic, Lao PDR, Latvia, Lebanon, Lithuania, Macedonia FYR, Madagascar, Malawi, Malaysia, Mali, Mauritania, Mauritius, Mexico, Moldova, Mongolia, Morocco, Mozambique, Namibia, Nepal, Netherlands, New Zealand, Nicaragua, Niger, Nigeria, Norway, Pakistan, Panama, Papua New Guinea, Paraguay, Peru, Philippines, Poland, Portugal, Romania, Russian Federation, Rwanda, Senegal, Sierra Leone, Slovak Republic, Slovenia, South Africa, Spain, Sri Lanka, Sweden, Switzerland, Syrian Arab Republic, Tajikistan, Tanzania, Thailand, Tunisia, Turkey, Uganda, Ukraine, United Kingdom, United States, Uruguay, Venezuela RB, Zambia, Zimbabwe.

Table A3.2: Data Sources

Variable	Description	Data Source
Political Equality	Continuous measure assessing whether political power is distributed independently of socio-economic position, ranging from 0 to 4.	V-Dem database
PR	Dichotomous variable with 1 indicating proportional representation system and 0 otherwise.	Bormann and Golder (2013)
GDPpc (log)	Natural logarithm of gross domestic product (GDP) per capita, in constant 2010 US dollars	World Bank
BMR	Dichotomous measure of democracy on the basis of contestation -i) the executive is directly or indirectly elected in popular elections and is responsible either directly to voters or to a legislature; ii) the legislature (or the executive if elected directly) is chosen in free and fair elections-, and participation -iii) a majority of adult men has the right to vote.	Boix et al. (2013)
Dependency ratio	Age dependency ratio is the ratio of dependants (aged under 15 or over 64) to the working-age population (those aged 15-64). Percentage.	World Bank
Inflation	Annual inflation rate	V-Dem & Clio Infra (clio-infra.eu)
Trade	Exports and imports as a percentage of GDP	World Bank
Age of democracy	Consecutive years of democratic regime type	Boix et al. (2013)
Education	Average years of education among citizens older than 15.	V-Dem database
Stock market	Domestic and foreign shares traded multiplied by their respective matching prices as a percentage of GDP. Data are end of year values.	World Bank

Table A3.3: Data Sources Additional Covariates

Variable	Description	Data Source
FDI	Net inflows (new investment inflows less disinvestment) in the reporting economy from foreign investors, as a percentage of GDP.	World Bank
KOFecon	KOF index of Economic Globalization	Gygli et al. (2018)
KOFsoc	KOF index of Social Globalization	Gygli et al. (2018)
KOFpol	KOF index of Political Globalization	Gygli et al. (2018)
Turnout	Percentage of the total population who voted in the same election	Vanhanen and Lundell (2014)
No compulsory voting	Dichotomous variable equal to 0 for compulsory voting for those eligible to vote in national elections and 1 otherwise.	V-Dem database

Table A3.4: Changes in Electoral Systems

Algeria	1997	Kyrgyz Republic	2007
Bolivia	1997	Madagascar	1998
Bulgaria	1991	Moldova	1994
Bulgaria	2009	Morocco	2002
Bulgaria	2013	Poland	1991
Cameroon	1997	Portugal	1980
Sri Lanka	1989	Romania	2008
Croatia	2000	Sierra Leone	2002
Ecuador	1998	Turkey	1987
Ecuador	2002	Turkey	1995
Greece	2007	Ukraine	2006
Greece	2012	Macedonia FYR	2002
Italy	1994	Russian Federation	2007
Italy	2006	Venezuela RB	1993
Kazakhstan	2007		

Table A3.5: Cross-correlation of Political Variables

Variables	PR	Political Equality	Democracy (BMR)
Political Equality	0.160		
Democracy (BMR)	0.337	0.379	
Age of democracy	-0.069	0.241	-0.025

Figure A3.1: Political Equality and Redistribution (2005)

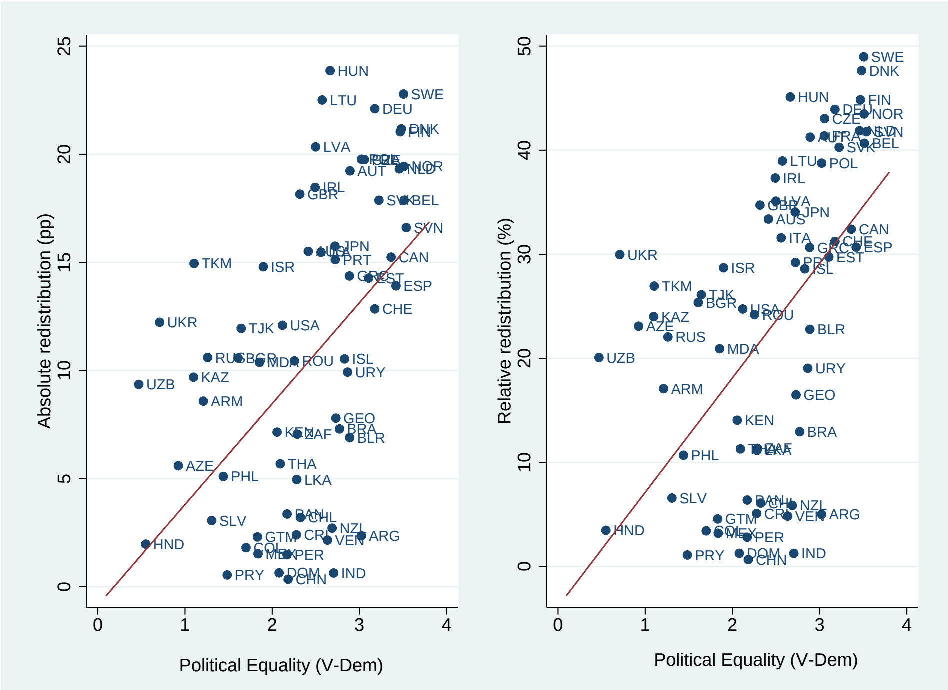


Table A3.6: Political Equality by Type of Regime

Variable	Mean	Std. Dev.	Min.	Max.
Non-democracies				
Political Equality	1.89	.892	.126	3.726
Democracies				
Political Equality	2.556	.721	.094	3.799

4 — Graduates' opium? Cultural values, religiosity and gender segregation by field of study

"[O]ld forms of gender inequality are weakened but new forms of gender inequality emerge".

Diane Elson, 2009, pg. 1

4.1 Introduction

Women currently outnumber men in virtually all higher education systems in Western countries. Nevertheless, women and men are strikingly concentrated in specific fields of study. This horizontal gender segregation in higher education results in the over-representation of women in some specific fields (generally in care and humanistic-related fields) and the over-representation of men in others (generally, in technical and science-related fields) (Barone, 2011).

Horizontal gender segregation in education is considered an issue of first-order importance insofar as it shapes the skill composition of the future workforce (Altonji et al., 2015) and thus may represent a hurdle for labour market productivity gains and economic development (Dollar and Gatti, 1999; Knowles et al., 2002). Furthermore, gender segregation in education accounts for a notable share of the gender wage gap (Brown and Corcoran, 1997; Blau and Kahn, 2000; Bobbitt-Zeher, 2007). Indeed, the female shortfall in the fields of science, technology, engineering, and math (STEM) has recently attracted the attention of scholars (Sassler et al., 2017; Card and Payne, 2017; Kahn and Ginther, 2017) and is a major concern in educational and labour market policy-making (EIGE, 2014; SheFigures, 2012).

Social scientists from different disciplines point to socio-economic factors, such as gender differentials in career and family aspirations, gender-based discrimination, and cultural values as major causes of horizontal gender segregation in education (Ceci et al., 2014). Yet, the theories of horizontal gender segregation in education have not been systematically examined using actual trends (Mann and DiPrete, 2013). Bertrand (2017) argues that the scarcity of women on particular educational tracks might be partly driven by constraints expected by women in the jobs associated with those tracks, and highlights the need for further research to help understand the full set of determinants of current gender disparities in educational outcomes. This paper seeks to close this gap by focusing on the role that cultural values play in horizontal gender segregation in higher education from a cross-country time-series econometric approach. Anti-egalitarian gender attitudes have previously been found to slowdown gender convergence in labour market outcomes (Fortin, 2005). The literature also associates religiosity with more traditional gender roles and less favourable attitudes towards working women (Guiso et al., 2003; Algan and Cahuc, 2006). These accounts motivate the current paper to assess the impact of two focal cultural values, namely gender-egalitarian social norms and levels of religiosity, on the gender distribution of higher education graduates across fields of study.

To map segregation trends, I combine national-level measures of gender segregation with disaggregated indices of gender segregation in 9 fields and 23 subfields of study for a panel of 26 Organisation for Economic Co-operation and Development (OECD) countries for 1998-2012. This combination of data allows us to uncover patterns of gender segregation that remain concealed when aggregate data on higher education are used. Hence, I am able to identify the precise fields and subfields that drive national-level gender segregation. Cases in point are of agriculture, a generally male-dominated field made up of a highly male-dominated subfield (*agriculture, forestry and fishery*) and a highly female-dominated subfield (*veterinary*), among other fields of study.

I link the data on horizontal gender segregation in higher education with information on two focal cultural traits: gender equality and religious beliefs. I measure country-level gender equality -or the lack thereof- by means of either the Gender Inequality Index of the United Nations Development Programme (UNDP) or the Gender Equality index of the International Institute for Democracy and Electoral Assistance (IDEA). I use the level of religiosity obtained from five waves (1990-94; 1995-98; 2000-04; 2004-09; 2010-2014) of the World Value Survey (WVS) as a measure of the extent to which social norms are attached to traditional gender roles (Inglehart, 2014).

To isolate the impact of cultural values, I control for economic structural changes, labour market and education system features, along with marriage market indicators, such as fertility and divorce rates, as potential determinants of gender disparities in education choices. Finally, I attempt to control for gender gaps in academic performance and self-reported math beliefs among young people that might relate to choices at later stages of their education (Ceci et al., 2014; Eccles and Wang, 2016). I use two waves of survey data (2003 and 2012) collected from the Programme for International Student Assessment (PISA) to construct aggregate indices of gender differences in anxiety, self-concept and self-efficacy towards mathematics.

The main finding suggests that there is a significant relationship between religiosity and lower levels of gender segregation. The indices of gender equality or inequality are not found to be significantly related to horizontal gender segregation. Gender gaps in math beliefs among young people are found to be correlated with higher gender segregation, which hints at an important link between attitudes acquired in early stages of the life-time and later education choices. Field and subfield-specific analyses provide a bigger picture of these correlations. The disaggregated results suggest that religiosity might be conducive to lower gender segregation in the fields of agriculture and health and welfare, and more specifically in the subfields of *mathematics and statistics*, *agriculture, forestry and fishery* and *social services.*

The remainder of the paper is structured as follows. Section 2 provides reasons for considering a link between culture and gender segregation. Section 3 describes the data. Section 4 specifies the empirical strategy. Section 5 shows national, field and subfield-level results. Section 6 concludes.

4.2 Gendered choices of field of study

Standard economic literature considers the choice of major as a dynamic process of decision-taking under uncertainty in which individuals make assumptions so as to infer the outcomes of their specific, field-of-study choices (Altonji, 1993; Arcidiacono, 2004; Zafar, 2013). Those assumptions may include neoclassical economic explanations such as foreseen family burdens and discrimination to explain gender disparities in education choices[1]. Experimental economics, for its part, seems to debunk the often-repeated arguments of innate gender differentials in cognitive skills by showing that gender gaps in risk-taking, competitive-leaning and social beliefs drive gendered choices of fields of study (Croson and Gneezy, 2009; Buser et al., 2014).

Parallel to these explanations, economic research on cultural values emphasizes the role of gen-

[1] The canonical arguments of gender segregation are framed in rational choice theory and are divided into demand-side factors (Mincer and Polachek, 1974) and supply-side factors (Becker, 1957). For recent research see Goldin (2006, 2014a,b)

der identity and social norms in shaping the economic behaviour of people (Guiso et al., 2006; Blau et al., 2013; Giuliano, 2017)[2]. The shift from traditional to egalitarian social norms regarding gender roles has paved the way towards gender convergence in educational investment and labour market outcomes (Fortin, 2005; Mandel and Semyonov, 2006). On this bedrock of cultural values, Guiso et al. (2003) affirms that religion is likely to affect every aspect of life in society. Using World Value Survey data, they associate religiosity with less favourable attitudes towards working women. Algan and Cahuc (2006) assess the attachment of religion to traditional family values that favour a male breadwinner division of labour. They document differences between religion denominations, in which Catholics and Muslims are more likely to agree with traditional gender role prescriptions than Protestants or non-religious people. Based on these different prescriptions on the role of working women across societies, one might consider that culture can either encourage or hinder gender divergence in choices of major in higher education.

The epidemiological methodology developed in Fernández (2008) reinforces the explanatory power of the intergenerational transmission of gender norms on gender disparities in both individual and constrained preferences in the labour market and educational choices (Farré and Vella, 2013; van de Werfhorst, 2017; Charles et al., 2018). However, the role of culture has not been addressed in international comparisons of horizontal gender segregation in education in depth due to scarcity of data available. Drawing on the empirical evidence supporting the idea that economic outcomes and social beliefs are correlated (Fernández, 2011), the current paper considers whether cultural values (e.g. gender equality and religion) play a role in horizontal gender segregation in higher education.

Gender segregation explanations drawn from prior mathematical achievement have been steadily replaced by findings suggesting that gender disparities in perceived ability have stronger effects (Friedman-Sokuler and Justman, 2016; Justman and Méndez, 2018). Eccles and Wang (2016) use survey data on 1,200 college-bound students in Michigan (U.S.) to study whether their self-concept of math ability in 12th-grade (age 17-18) encouraged them to choose STEM occupations at age 29. Their results indicate that gender differences in the likelihood of entering STEM careers were strongly predicted by math self-concept, together with lifestyle expectations, demographics and high school course-taking, rather than by actual math performance. In a similar vein, Shi (2018) uses data in the transition from high school to college for North

[2]Akerlof and Kranton (2000) provide a game theoretical model that defines an identity-based utility of individual choices. Obeying social prescriptions of one's identity as a "man" or as a "woman" is rewarded while violating them evokes anxiety and discomfort. Hence, this model defines non-pecuniary benefits derived from the choice of educational paths, as formulated for instance by Humlum et al. (2012) and Beffy et al. (2012).

Carolina (U.S.) to study female under-representation in engineering. She finds that the scarcity of women in engineering is partly explained by their relative lack of confidence in math abilities, but she finds gender disparities in preferences and professional goals to have stronger explanatory power. The empirical analyses below attempt to disentangle the potential segregative effects of cultural traits from those arising from disparities in math performance and math ability perceptions' between boys and girls.

This paper adopts a macro-level approach grounded on two earlier publications on gender segregation across fields of study: First, the paper by Charles and Bradley (2009), which uses a cross-country analysis of gender segregation in four fields of study for 44 countries in 1999; and second, the panel data analysis of US graduates in 225 fields between 1975-2002 by England and Li (2006). I depart from these previous papers by conducting a panel data analysis of gender segregation at national, field and subfield levels and focusing on cultural values while using more nuanced measures of gender gaps in math beliefs. Hence, my approach is intended to tackle both within-country time dynamics of segregation and by-subfield heterogeneity within gender-dominated fields (e.g. *veterinary* versus *forestry* within agriculture).

Due to data limitations, I can only test for macro-level relationships between cultural values and horizontal gender segregation in higher education. Cohort-data research finds gender differentials in education outcomes on the basis of demographics, such as immigration (Alonso-Villar et al., 2012), socio-economic status (Bailey and Dynarski, 2011; van de Werfhorst, 2017), parents' educational attainment and labour market participation rates (Fernández, 2013; Farré and Vella, 2013), role models of teachers and parental expectations (Bettinger and Long, 2005; Xie et al., 2003), and peer-related processes (Schoon and Eccles, 2014). The potential intersection between gender and demographics is left for future research.

4.3 Data on gender segregation

The OECD Education Database classifies the number of female and male graduates based on the International Standard Classification of Education (ISCED1997) in 9 broad fields of study (1 digit-level) and 23 narrow fields of study (2 digit-level), which I refer to as subfields (see Table A4.1 in the Appendix A). I collect data for 26 OECD countries for 1998-2012[3]. Using data on graduate completion instead of enrolment rates mitigates issues of attrition in gender-atypical choices, specifically in female students (Mastekaasa and Smeby, 2008). To the

[3]See Andersson and Olsson (1999) for an explicit definition of the subfields considered in each of field of study.

best of my knowledge, this data allows for the greatest country coverage, time span and data disaggregation to compute gender segregation indices. I use two nominal measures of gender segregation: The Dissimilarity Index (Duncan and Duncan, 1955) and the Association Index (Charles and Grusky, 1995). The former provides information at national-level and the latter at field or subfield-levels of segregation[4].

4.3.1 Country-level segregation: Dissimilarity index

The index of dissimilarity (ID hereafter) was first developed in racial segregation studies by Duncan and Duncan (1955). The ID is one of the primary measures of segregation applied to the context of gender segregation in labour markets and education (Gelbgiser and Albert, 2017). It is given by the following formula[5]:

$$ID = \frac{1}{2} \sum_i \mid \frac{F_i}{F} - \frac{M_i}{M} \mid *100 \tag{4.1}$$

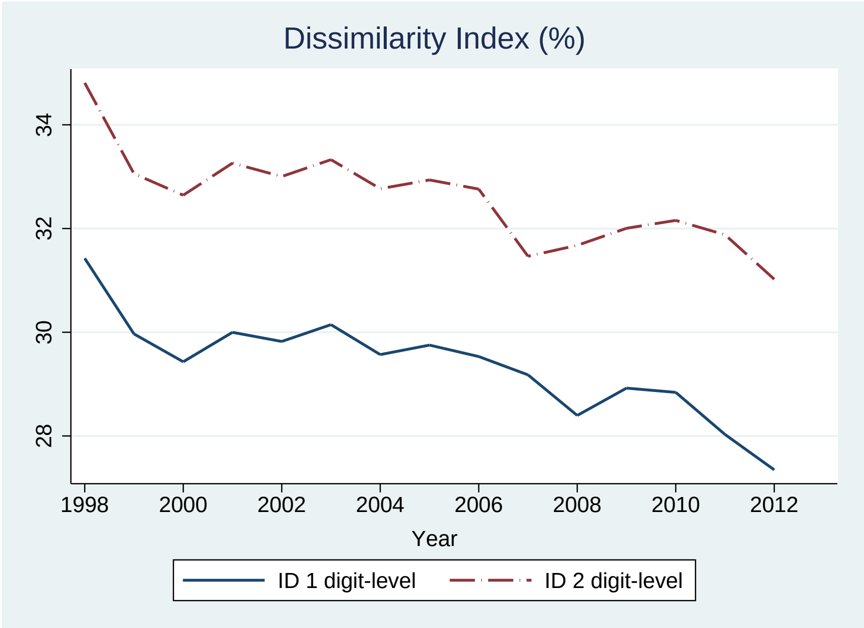
where F_i and M_i are females and males in field or subfield i, F and M are the total numbers of female and total male graduates respectively. As defined in Duncan and Duncan (1955), the ID provides the percentage of women who would have to change fields without replacement in order to make their distribution identical to that of men. The index takes values from 0%, indicating total gender integration across fields, to 100%, indicating complete gender segregation.

Figure 4.2(a) shows the trend of the sample average ID computed based on broad (ID at 1 digit-level, blue line) and narrow (ID at 2 digit-level, red line) classifications of higher education. The ID is sensitive to the techniques and categorizations used in defining fields (Reskin, 1993; Nelson, 2017). Consequently, the ID can be manipulated into being smaller (by using very broad categories) or larger (by using narrow categories). This sensitivity is evident in the different average levels taken by the ID in broad or narrow categorizations (disaggregation at 1

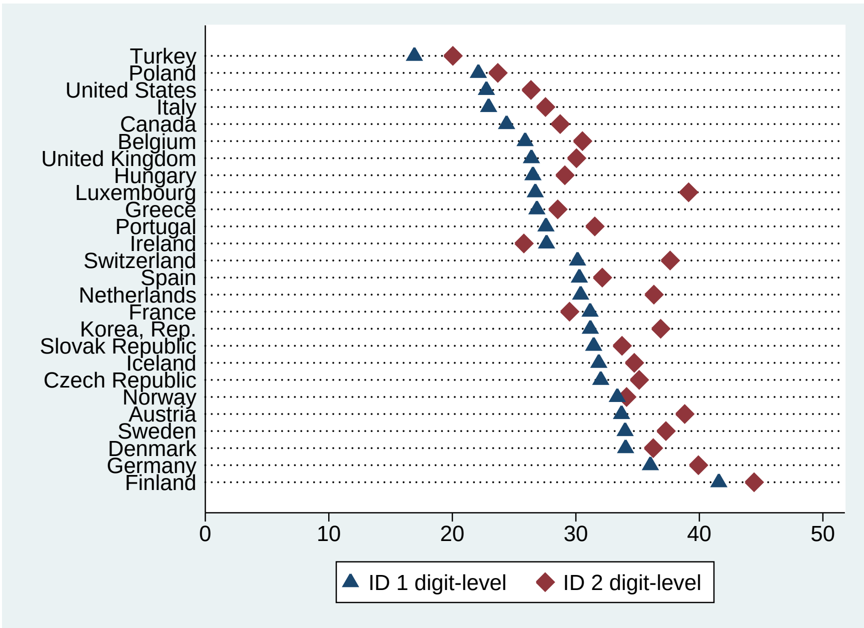
[4]In sharp contrast to ordinal measures, nominal measures of segregation do not take into account a hierarchical ordering of the education system (Semyonov and Jones, 1999). A large body of American literature on the pay-offs to human capital suggests that generally female-dominated fields (humanities and social science) result in lower incomes than male-dominated fields (scientific and technical fields) (Charles and Bradley, 2009). Nevertheless, given the lack of specific data on wages associated with each field or subfield for the sample of countries, the current paper does not distinguish between female and male-dominated fields in any income or social status ordering.

[5]Cross-national and inter-temporal comparisons using the ID might entail computational issues due to its sensitivity to the share of fields in total higher education (Charles and Grusky, 1995; Watts, 1998). If education systems are dominated by one highly segregated field, the ID would yield higher values than if the dominant field was evenly composed by women and men, and numerous small fields were highly segregated. Note that the number of graduates in each field as a proportion of the total graduate body remain stable over the period analysed, as shown in Figure A4.1, Appendix A.

Figure 4.1: Country-level Horizontal Gender Segregation



(a) Trend



(b) By country

digit-level *vs.* 2 digit-level), where the latter give higher figures for segregation. Regardless of the category used to compute the ID, the indices show a decreasing trend in 1998-2012, with a drop of around 3 percentage points (pp) by the end of the period. However, ID values remain quite stable throughout this period in comparison with de-segregative fashion taken from 1970 to 1990 (England and Li, 2006; Mann and DiPrete, 2013; Bronson, 2014). This might feed into the afore-mentioned slowdown in gender integration in higher education and other areas of society since the mid-1990s (see *inter alia* Blau et al. (2006); Olivetti and Petrongolo (2016)).

Figure 4.2(b) shows average levels of the ID computed at 1 digit-level (blue) and 2 digit-level (red) for each country in the sample. Turkey is the least segregated country in the sample (an ID of 17.1% at 1 digit-level), whereas Finland is the most segregated (42.1%). Cross-country comparisons show that more affluent, more gender-egalitarian countries have greater segregation (e.g. Scandinavian countries[6]). This observation challenges rational choice theories that predict less segregation as societies become economically richer and gender egalitarian (see Estevez-Abe (2005)). Economists note that gender disparities that do not clearly define hierarchical structures relative to vertical disparities are less easily undermined (Goldin, 2006; Shavit et al., 2007). Thus, horizontal segregation in higher education can reconcile gender-egalitarian and gender-essentialist values to a greater extent[7]. Indeed, this conundrum is already formulated as the *education-gender-equality* paradox in other social science disciplines (Stoet and Geary, 2018).

4.3.2 Field and subfield-level segregation: Association index

I combine the data on country-level gender segregation with data on field-level segregation and subfield-level segregation. To that end, I use the log-linear modelling approach from Charles and Grusky (1995), namely the Association Index (A_i henceforth), which provides the factor at which each field or subfield of study is associated with a gender (female or male)[8]. The A_i index is computed as follows[9]:

$$A_i = ln\frac{F_i}{M_i} - [\frac{1}{j} * \sum ln(\frac{F_i}{M_i})] \tag{4.2}$$

where ln is the natural logarithm, j is the number of fields (this number is 9 when the ISCED1997 1 digit-level is used and 23 for the ISCED1997 2 digit-level), F_i is the number of women in field i and M_i is the number of men in field or subfield i. Positive values of the A_i

[6] Studies on Scandinavian labour markets (Albrecht et al., 2003; Evertsson et al., 2009; Carlsson, 2011) suggest that the disparities in expansion of the welfare state across developed countries (e.g. care work transfers from families to the public sectors), might be a potential driver of cross-country differences in women's concentration by fields of study.

[7] This logic corresponds to "separate-but-equal" gender beliefs as a cause of persisting horizontal gender segregation as suggested by Charles and Bradley (2009) and England (2010).

[8] See Charles and Bradley (2002, 2009), Barone (2011) and Mann and DiPrete (2013) for applications of the index in the context of segregation in education. Following the sociological literature in which this index was developed, I use the term of "gender-labelling" of fields, although the term "gender-typing" is also used in the literature.

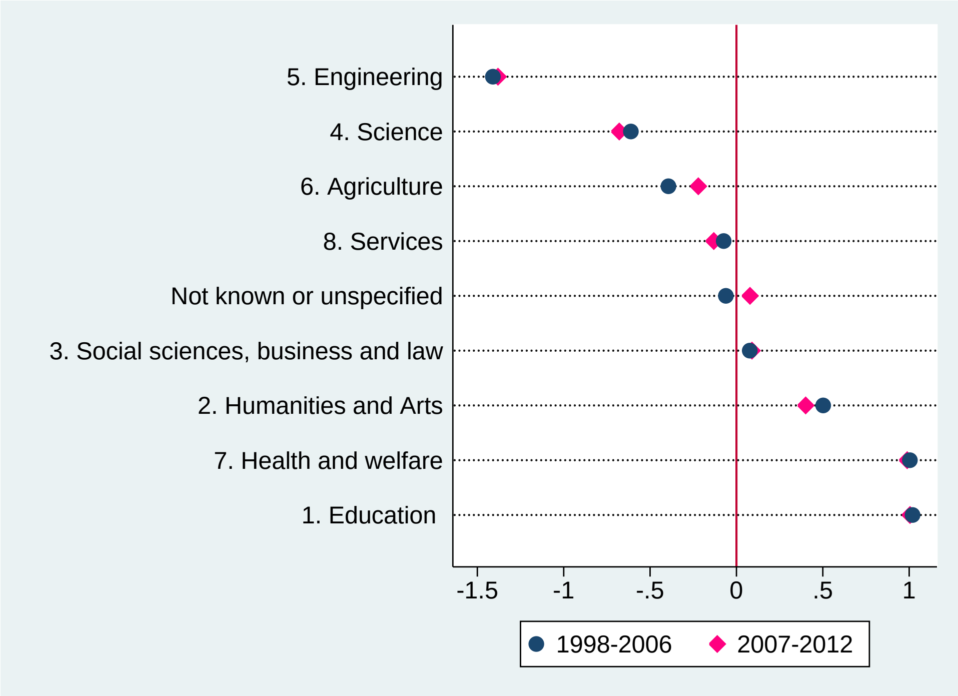
[9] One technical advantage of this measure is that using log-linear techniques means that the measure is affected by neither the share of each field in different countries nor the proportion of women among graduates. Hence, the A_i index outperforms ID in cross-country and inter-temporal comparisons. See Blackburn et al. (1993); Watts (1998) for these computational issues of segregation indices.

indicate that the field is associated with women, near zero values indicate gender-neutrality, and negative values that the field is associated with men. A well-suited feature of the association index is that it compares the extent of segregation of male-dominated and female-dominated fields or subfields.

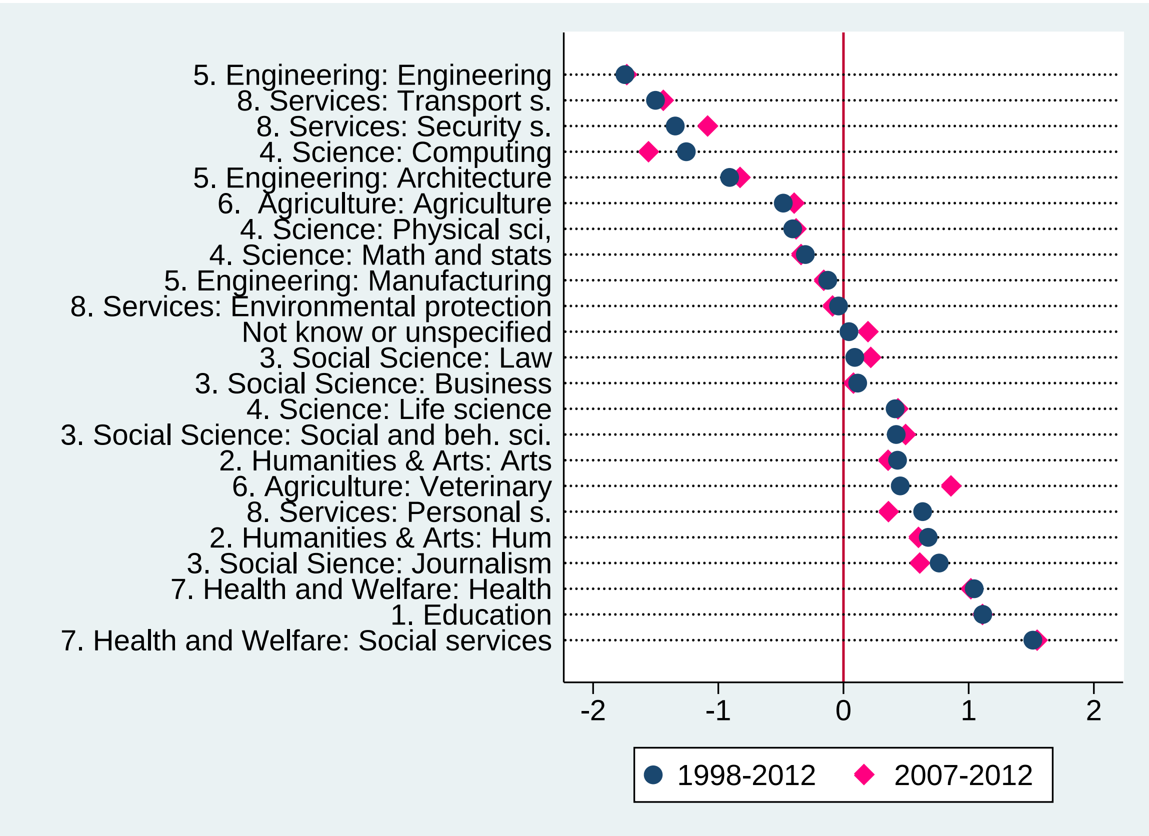
Figure 4.3(a) shows the average factor of gender-labelling of fields ordered from most male-dominated to the most female-dominated for 1998-2006 and 2007-2012. Engineering is the most segregated field, that happens to be male-dominated showing an A_i of -1.5. Science and agriculture are also male-dominated, although to a lesser extent than engineering. Fields placed in the middle of the table, with values around zero, are gender-neutral fields (services and social sciences). Humanities and arts comprises a female-dominated field, with values close to 0.5. Finally, education and health and welfare are the most female-dominated fields with values around 1, and the most segregated fields after engineering. The gender labelling of fields remains similar before and after the Great Recession, although agriculture and humanities are slightly less segregated and science is more segregated on average in 2007-2012. This descriptive data is consistent with the care-technical and humanistic-scientific divides highlighted in Barone (2011).

Figure 4.3(b) reveals high heterogeneity in gender-labelling within fields of study. The field of engineering is divided into three subfields with varying factors of gender-labelling: *Manufacturing* is slightly male-dominated, with an index close to zero (-0.16), whereas *engineering* and *architecture* are more male-dominated with values of -1.7 and -0.83. The overall male-dominated fields of science and agriculture have also female-dominated subfields, such as *life science* and *veterinary* studies. Similarly, the field of services is made up of highly male-labelled subfields (*transport services* and *security services*) plus a female-labelled subfield (*personal services*). The most segregated subfields are *engineering* (male-labelled) and *social services* (female-labelled). Averages from before-and-after the Great Recession show that *computing* and *veterinary* are more segregated in 2007-2012, whereas *security services* and *personal services* are less segregated in this latter period.

Figure 4.2: Field and Subfield Gender Segregation - Association Index



(a) Broad Classification



(b) Narrow Classification

4.4 Empirical strategy

The hypothesis that I test is whether cultural values play a role in the gender distribution across fields of study in higher education. I first specify panel data regression models using country-level segregation (ID) as the left-hand-side (LHS) variable, computed using either a broad (field) or narrow (subfield) classification of higher education.

$$ID_{ct} = \beta_0 + \beta_1 CulturalValues_{c,t-4} + X'_{c,t-4}\beta + \gamma_t + \alpha_c + u_{ct}$$
$$c = country; t = year \quad (4.3)$$

where ID_{ct} is the dissimilarity index in country c in year t, γ_t and α_c are time and country fixed-effects respectively. $CulturalValues_{c,t-4}$ is the focal explanatory variable referring to either country-level gender equality or religiosity. $X_{c,t-4}$ is a set of control variables. Following England and Li (2006), I lag the full set of independent variables four years behind the dependent variable to alleviate causality issues. Considering that the data covers all types of higher education graduates (2-year college, bachelor degrees, masters and Ph.D.) a time span of four years to completion might be reasonable. I am aware of the difficulty of interpreting the results below as causal effects, so I follow the literature to ease the exposition of the results by talking about "impacts" or "effects". The reader should interpret the results below as mere correlations. Baseline models are computed based on information for 26 countries, although the sample of countries is reduced to 18 when WVS data are used and to 17 for PISA data (see summary statistics and sample countries in Table A4.2, Appendix A).

4.4.1 Measures of cultural values: Gender (in)equality and religion

I employ the Gender Inequality Index (GII hereafter) taken from the UNDP (see Jāhāna (2016) for methodology). This index measures the loss of human development derived from gender-based discrimination in three main dimensions (health, empowerment and the labour market), where higher values mean greater gender inequality[10]. As an alternative measure of gender-egalitarian values, I use the IDEA Gender Equality index. This index is operationalized using five indicators: Power distribution by gender, female participation in civil society organizations, the ratio between mean years of schooling for women and men, the proportion of lower chamber

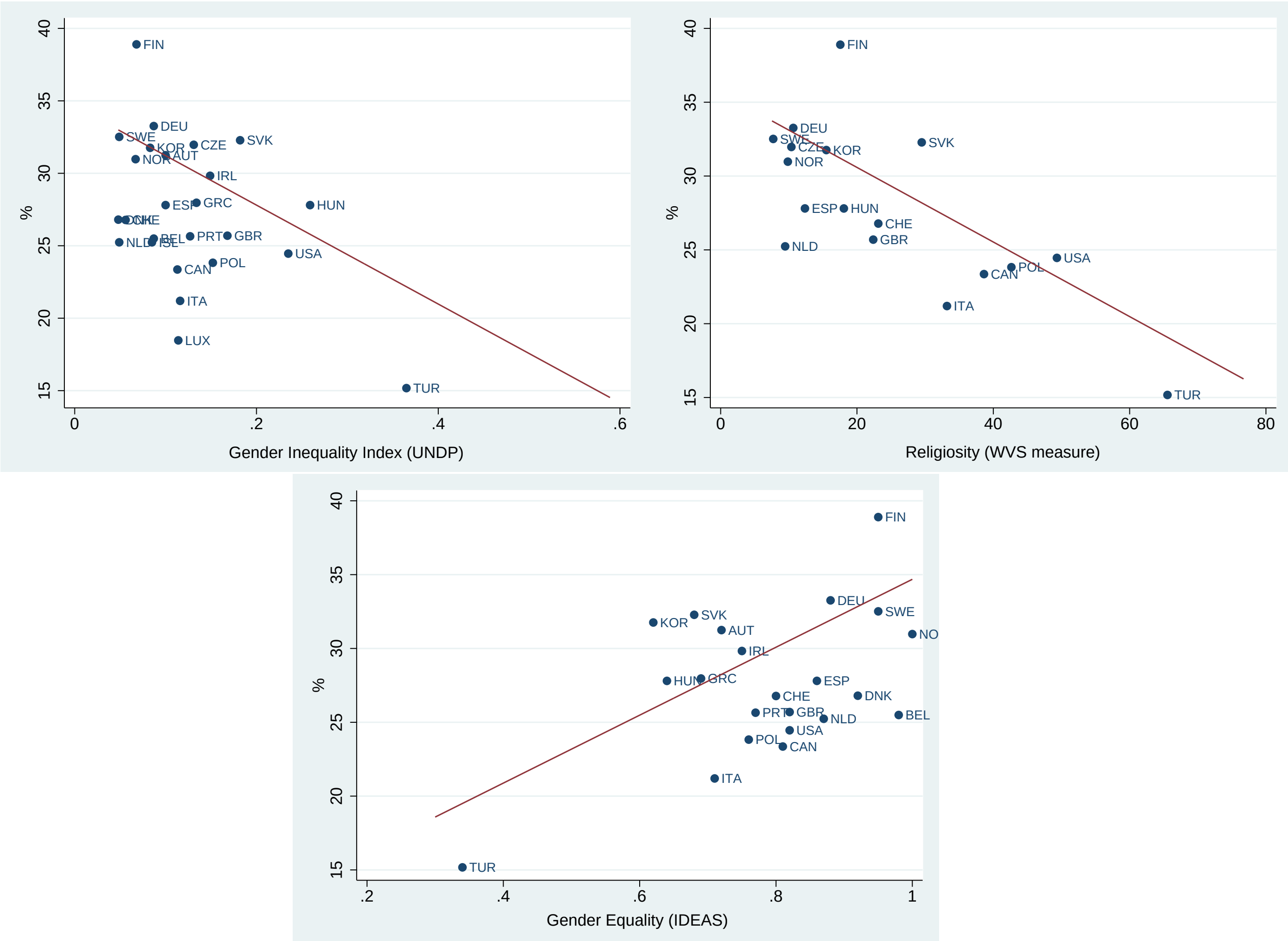
[10]In spite of other measures used in related literature, such as the World Economic Forum's gender gap index in González de San Román and de La Rica (2016); Rodríguez-Planas and Nollenberger (2018), the GII is available for a longer period (2000, 2005, 2010, 2011 and 2012).

female legislators, and the proportion of women in ministerial-level positions (Skaaning, 2017). I use five waves (1990-94; 1995-98; 1999-04; 2005-08; 2010-12) of the WVS to measure country-level religiosity. It is measured by the proportion of WVS respondents who, on a 0-10 scale, give a score of 10 for the statement *"God is very important in my life"*. This statement is present in all WVS waves, whereas other religion-related WVS questions were asked in fewer waves. Average values for GII, Gender Equality and religiosity by country can be found in Figure B4.1 in the Appendix B.

Gender-unequal cultural values are thought to reinforce gender-essentialist ideals, i.e. widely shared beliefs that women are better at caring, nurturing, and human interaction whereas men excel at abstract thinking, problem solving, and analysis (Sikora and Pokropek, 2012; Charles et al., 2015). Anti-egalitarian values might be expected to shape gendered identities of individual men and women to encourage the choice of gender-confirming fields of study, and thus increase segregation. At the same time, the evidence states that more religious ideologies go in lockstep with traditional division of labour and gender roles, which might lead to the expectation of higher levels of segregation in more religious societies.

Figure 4.3 challenges this view by showing scatter plots of the three alternative proxies of cultural values and gender segregation at national level (dissimilarity index) in 2012. Both higher gender inequality and religiosity are negatively correlated with segregation, meaning that in less gender-egalitarian and more religious societies gender segregation is lower. By contrast, greater gender equality is positively correlated with horizontal gender segregation in higher education.

Figure 4.3: Gender Segregation and Cultural Values



Correlations between GII (UNDP), Religiosity (WVS) and Gender Equality (IDEA) and Dissimilarity Index at 1 digit-level, for 2012

4.4.2 Control variables

The term $X_{c,t-4}$ is a vector of variables measuring economic, labour market and educational institutions that previous literature has related to horizontal gender segregation. The marriage market and gender gaps in math beliefs are also considered. Data sources and pairwise correlations of the explanatory variables are relegated to Tables A4.3 and A4.4 in the Appendix A.

Economic and labour market features

Flexibility in gender divisions of labour in interconnected and densely populated areas might affect gendered choices of educational paths (Stockemer and Sundström, 2016; Evans, 2018). That mechanism is controlled for here by including the population density (Pop. density), measured by the number of people per km^2 of land area. Structural changes in post-industrial economies are everywhere associated with increases in the weight of the service sector, rising female employment and changes in social norms (Goldin, 1990; Olivetti and Petrongolo, 2014, 2016; Ngai and Petrongolo, 2017). I control for the share of employees in the service sector to total employment (% Services) and the female labour force participation rate (Female Labour Force). At the same time, I include the percentage of professionals who are female (% Prof. Fem) in an effort to capture how upgrading female occupational status may predispose women to seek training in male-dominated fields, such as engineering or science (Polachek, 1987; Ramirez and Wotipka, 2001)[11].

Education system and performance

The models include three main features of higher education: The number of graduates as a proportion of the total population (Size Grads), the percentage of women in the total graduate student body (% Grad. Fem) and the breadth of vocational education via the number of graduates in ISCDE1997 level 5 Type B as a proportion of total higher education (Diversification). Charles and Bradley (2009) suggest that the democratization of higher education might erode the elite luster of universities, therefore reducing the proportion of students who possess an elite identity and sense of self-efficacy, which might be required to transgress gender social norms governing educational choices. A similar logic is provided regarding the greater proportion of women in the whole graduate body[12]. Finally, the expansion of vocational studies in higher education, proxied by diversification, has been previously found to increase gender segregation (Brunello and Checchi, 2007; Blossfeld et al., 2015; Hillmert, 2015).

To rule out gender segregative effects of disparities in boys and girls' academic performances, I include the gender gap in academic performance (boys' scores minus those of girls) in secondary education (Performance Gap). I use the Quality of Education Database provided by Altinok et al. (2014) who combine panel data on math and science scores from PISA and the Trends in International Mathematics and Science Study (TIMSS). Whenever possible, their database focuses on math scores, but it takes into account growth rates of scores in science for countries

[11]Gender disparities in labour market outcomes provide newcomers to higher education with information on labour market pay-offs of educational choices (Xie and Shauman, 1997), and female labour status has indeed been used in earlier studies to proxy societal attitudes towards gender roles (Fortin, 2005).

[12]Previous studies are inconclusive on whether the dominance of women in overall higher education is positively or negatively related to gender segregation. As women increase their presence in higher education, fewer female students might regard themselves as exceptional or pioneers, so they will be less likely to opt for male-dominated fields (Charles and Bradley, 2009). On the contrary, if vertical and horizontal gender ascription move together according to common social conditions (England and Li, 2006), the proportion of women in higher education and segregation by fields should be positively related.

which did not take part in an evaluation in maths[13].

Marriage market

The set of controls also includes fertility and divorce rates. Goldin (2006) argues that these indicators were among the underpinnings of the transformation of women's role in the labour market from a job-focus to a career-design in the aftermath of World War II. They might in turn foster a convergence between men and women's choices of education paths.[14]. Along these lines, past papers find that gender discrepancies in marriage aspirations and family formation plans to impact on the share of women in math-related and female higher educational attainment (Badgett and Folbre, 2003; Ceci et al., 2014; Bronson, 2014; Attanasio and Kaufmann, 2017). The current paper controls for these marriage market features, supplementing existing international analyses of segregation such as that of Charles and Bradley (2009).

Attitudes of young people towards math

I use the 2003 and 2012 waves of PISA surveys which focused on mathematics (OECD, 2013). This in-depth focus provides data on self-reported beliefs regarding math anxiety (measured by means of students' responses about feelings of stress and helplessness when dealing with mathematics), math self-concept (based on students' responses about their perceived competence in mathematics), and math self-efficacy (based on students' perceived ability to solve a range of pure and applied mathematical problems).

PISA assesses these self-reported math beliefs on the basis of strong agreement or agreement on a number of items in each dimension, which are relegated here to the Appendix C. I compute gender gaps in national-level indices of math anxiety, self-concept and self-efficacy based on average agreement with the items for each dimension[15]. In virtually all the countries in the sample girls are more likely to report math anxiety and less likely to report a self-concept of math than boys. As for math self-efficacy, boys generally report higher levels than girls, although there is some heterogeneity depending on the item in question. Based on the sample of countries, girls show higher levels of self-efficacy in items related to equations (first and second

[13]The sample average score for boys is 567.7 whereas for girls is 563.0.

[14]Goldin (2006) accounts for a *quiet revolution* that transformed American women's horizon, identity and decision-making in the aftermath of World War II. Increasing divorce rates, age of first marriage and more agency about female reproductive decisions were among the major underpinnings of that revolution.

[15]PISA provides scale indices of self-reported math beliefs measuring the distance from national levels to average of the total sample of countries participating in PISA surveys. It would be misleading to link these scale indices with my database of gender segregation because my panel is unbalanced and only covers a cluster of OECD countries. Thus, I construct aggregate-level gender gaps in self-reported math beliefs instead of using scale indices in OECD (2013)

order linear equations). However, boys score higher than girls in the rest of the self-efficacy items. I compute gender gaps for these indices based on the gender that shows higher levels of these self-reported math beliefs: Math anxiety gender gaps are computed as girls' indices of math anxiety minus that of boys, whereas gender gaps in self-concept and self-efficacy are computed as boys' indices minus those of girls.

Figure 4.4: Gender Gaps in Self-reported Math Beliefs

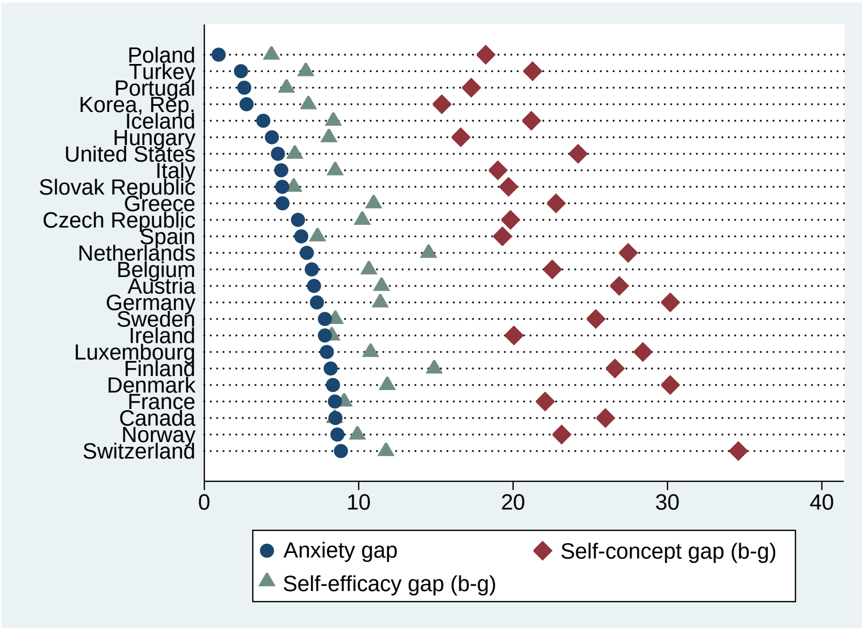


Figure 4.4 shows average gender gaps between 2003 and 2012 in math anxiety (blue points), math self-concept (red diamonds) and math self-efficacy (green triangles) in the sample of countries, which are listed from lower to higher gender gaps in math anxiety. Switzerland, Norway, France and Canada show the biggest levels of gender gaps in math anxiety, while Poland, Turkey, Portugal and the Republic of Korea show the lowest. Gender gaps in math self-concept are larger than for math anxiety, gender gaps in math self-efficacy are closer to those of math anxiety. The data displays a pattern in which affluent and more gender-egalitarian countries generally have wider national gender gaps in self-reported math beliefs than less affluent countries, as found by Stoet et al. (2016). Figure C4.1 in the Appendix C provides scatter plots of ID and gender gaps in self-reported math beliefs. In all three cases, the plots tend to positively correlate wider gender gaps for young people with gender segregation in higher education.

To control for gender gaps in math beliefs, I apply a linear adjustment for 2003-2012 under the assumption of an equal year by year change in math beliefs over that time. Notice that segregation data spans 1998-2012 and using lags of math beliefs would substantially reduce the number of years (2008-2012) and thus of observations. Hence, following previous literature, I study the contemporaneous effect of math attitudes of young people and gender segregation in higher education graduates. This data does not measure the effects of gendered attitudes towards math at individual level, but it enables me to assess to a certain extent whether patterns of gender segregation correspond to aggregate-level gender differences in math anxiety, self-concept or self-efficacy. The approach here seeks to supplement the cross-country analysis in Charles and Bradley (2009), in which they include TIMSS data on disparities in affinity for math between boys and girls.

$$ID_{ct} = \beta_0 + \beta_1 CulturalValues_{c,t-4} + \beta_2 MathBeliefs_{ct} + X'_{c,t-4}\beta + \gamma_t + \alpha_c + u_{ct}$$
$$c = country; t = year \tag{4.4}$$

As previously defined in Equation (4.3), ID_{ct} is the dissimilarity index in country c in year t, γ_t and α_c are time and country fixed-effects respectively. Note that the model includes contemporaneous $MathBeliefs$ (e.g. gender gaps in math anxiety, self-concept and self-efficacy), whereas the rest of independent variables are four years lagged.

4.5 Results

4.5.1 Country-level analysis

I estimate the model in (4.3) using the within-group estimator. The Breusch and Pagan post-estimation test confirms the presence of conditional heteroskedasticity in the data, so I use cluster standard errors at country-level and allow residuals to be correlated within but uncorrelated between countries (Cameron and Miller, 2015). The Hausman test' initial hypothesis that individual-level effects are adequately modelled by a random-effects model- is resoundingly rejected. Among other post-estimation tests, I take the issue of outliers by identifying observations with very large leverage or squared residuals. I use the lvr2plot Stata command (Cox et al., 2004) to analyse high leverage observations such as those for Turkey and Sweden separately. Excluding these two countries from the sample the results are unchanged.

A potential caveat on the validity of the estimation is concerned with endogeneity issues arising from the relationship between the ID (dependent variable) and the regressor $\%Grad.Fem.$ In separate models I use the Two Step Least Squared (2SLS) and the number of women in parliaments to instrument the share of female graduates (see Stockemer and Byrne (2011) for a justification of this instrument), and corroborate the main results of the paper. Indeed, post-estimation tests of the 2SLS approach fail to reject the hypothesis that the proportion of females in the graduate body is an exogenous covariate.

Table 4.1 shows that greater religiosity is associated with lower gender segregation four periods later. Yet the estimates of this effect become less significant when gender gaps in self-reported math beliefs are accounted for. Column 1 estimates a baseline model that includes the main set of control variables. The female labour force variable is associated with a negative impact on segregation which is consistent with previous research (Ramirez and Wotipka, 2001). Increasing female participation in higher education seems to be related to greater segregation by field of study, which is consistent with Charles and Bradley (2009). Nevertheless, that association is not robust to the inclusion of religiosity. The revolutionary indicators in Goldin's parlance, fertility and divorce, are associated with a significant negative and positive effect respectively on segregation. The effect of fertility is highly robust and challenges the idea that reducing fertility might foster a convergence between the educational choices of men and women.

Columns 2 and 3 (Table 4.1) introduce the GII and the Gender Equality index respectively, and are not associated with significant coefficients. Column 4 uses instead the level of religiosity, which enters with a negative and significant coefficient. This finding is in line with recent evidence on the link between more traditional societies and greater participation of women in math-related fields (Friedman-Sokuler, 2016), and the findings related to closer gender gaps in math performance in Muslim countries (Fryer Jr and Levitt, 2010). Ultimately, this negative correlation suggests that gender is less salient in higher education systems in more religious societies. This finding is consistent with that brought by Falk and Hermle (2018), who use survey data to provide evidence on that higher gender equality favour the manifestation of gender differences in preferences across countries.

I provide two mechanisms to tentatively explain the negative association between religiosity and gender segregation[16]: i) In more religious societies women play traditional role in the labour market (e.g. low female labour force participation rates and high fertility rates). As argued in Bertrand (2017), the constraints and challenges that women expect in the jobs associated with certain education tracks make women reluctant to choose them. Thus, if women expect to play a minor role in the labour market, their choices of majors may be less influenced by these future constraints and they will be more likely to opt for male-dominated education paths (e.g. STEM). ii) In more religious societies female participation in higher education is

[16]See Figure C4.2 in the Appendix for scatter plots of female participation in the labour force, share of graduates and fertility with religiosity.

relatively lower. Therefore, those women who do access higher education possess an elite identity that encourages them to transgress gender-confirming norms and opt for male-dominated fields (Charles and Bradley, 2009)[17].

I test these potential mechanisms by interacting religiosity with either fertility, female labour force participation rate or the proportion of women in the total number of graduates in separate models. These interactions are not associated with a significant effect, but estimates on the constitutive terms remain similar to the additive model in Equation (4.3). Due to the limitations of macro-level data used here, it goes beyond the scope of this paper to go further in these explanations.

[17] These tentative explanations are focused on the role of women. However, we can similarly assume that the role of men might also differ in religious and non-religious societies.

Table 4.1: Country-level Gender Segregation (Broad Classification)

Dependent variable: Dissimilarity index (1 digit-level)								
	Baseline	Cultural Values				Math Beliefs		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
L4.Pop. density	-0.002	0.066	0.018	-0.012	-0.220	-0.114	-0.152	-0.092
	(0.126)	(0.114)	(0.132)	(0.102)	(0.232)	(0.089)	(0.107)	(0.097)
L4.% Services	-0.074	0.010	-0.035	-0.031	-0.239	-0.207	0.012	-0.111
	(0.198)	(0.175)	(0.188)	(0.142)	(0.173)	(0.170)	(0.162)	(0.152)
L4.% Prof. Fem.	-0.038	-0.037	-0.037	-0.061	0.171*	0.003	0.082	-0.077
	(0.072)	(0.077)	(0.080)	(0.098)	(0.095)	(0.077)	(0.105)	(0.100)
L4.Fem. Labour Force	-0.881**	-0.747	-0.887**	-0.801***	-0.929	0.371	-1.228***	-0.592*
	(0.396)	(0.510)	(0.386)	(0.259)	(0.791)	(0.532)	(0.266)	(0.321)
L4.Grads Size	-1.796	-1.746	-2.818	1.470	-7.311***	2.692	1.974	1.317
	(2.351)	(1.961)	(2.496)	(2.389)	(2.106)	(2.371)	(2.518)	(2.173)
L4.Diversification	0.034	0.011	0.042	0.026	0.067***	-0.009	-0.009	0.019
	(0.032)	(0.022)	(0.032)	(0.036)	(0.020)	(0.032)	(0.033)	(0.034)
L4.% Grad. Fem.	0.117***	0.153**	0.124**	0.047	0.037	-0.001	0.054*	0.043
	(0.038)	(0.061)	(0.045)	(0.031)	(0.178)	(0.029)	(0.028)	(0.031)
L4.Performance gap	-0.072	-0.084	-0.037	-0.071**	-0.040	-0.029	-0.003	-0.058*

continues on next page

Table 4.1: Country-level Gender Segregation (Broad Classification)

Dependent variable: Dissimilarity index (1 digit-level)								
	Baseline	Cultural Values				Math Beliefs		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	(0.042)	(0.050)	(0.040)	(0.030)	(0.064)	(0.036)	(0.046)	(0.031)
L4.Fertility	-7.147***	-6.146**	-8.241***	-7.017***	-11.102*	-9.806***	-6.013***	-9.575***
	(2.501)	(2.438)	(2.608)	(2.251)	(5.593)	(3.129)	(1.592)	(2.570)
L4.Divorce rate	1.020**	0.836	0.934*	0.268	0.036	0.332	0.264	0.667**
	(0.460)	(0.531)	(0.451)	(0.325)	(1.136)	(0.270)	(0.235)	(0.255)
L4.GII		-12.406						
		(14.070)						
L4.Gender Equality			-18.475					
			(0.260)					
L4.Religiosity				-0.231***		-0.033	-0.081	-0.181**
				(0.062)		(0.065)	(0.050)	(0.068)
L4.% Catholic					1.353			
					(18.047)			
L4.% Protest.					18.116			
					(14.690)			
L4.% Muslim					-25.867			

continues on next page

Table 4.1: Country-level Gender Segregation (Broad Classification)

Dependent variable: Dissimilarity index (1 digit-level)								
	Baseline	Cultural Values				Math Beliefs		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
					(237.958)			
L4.% Jew					34.634			
					(316.463)			
Anxiety gap						0.637***		
						(0.193)		
Self-concept gap							0.367***	
							(0.109)	
Self-efficacy gap								0.550*
								(0.280)
No. of Obs.	218	180	196	136	75	128	128	128
No. of Groups	26	26	23	18	12	17	17	17
log-likelihood	-391.491	-299.735	-347.718	-214.043	-104.929	-194.005	-195.702	-200.472
Within R-squared	0.337	0.363	0.363	0.408	0.579	0.470	0.456	0.414

Country-level clustered standard errors in parentheses, * $p < .1$, ** $p < .05$, *** $p < .01$. Within-group estimates including time fixed-effects, constant terms not reported. Fourth period lagged explanatory variables except for variables of math beliefs.

Column 5 in Table 4.1 makes the case that different religion denominations might drive gender segregation. I use WVS data to obtain the proportion of Catholics, Muslims, Protestants and Jews in the sample of countries[18]. However, none of them are associated with a significant coefficient.

Columns 6-8 (Table 4.1) show within-group estimates of Equation (4.4). The results positively associate gender gaps in math beliefs of the youth with gender segregation. Recall that anxiety index is composed by girls' index minus that of boys whereas self-concept and self-efficacy are based on boys' index minus that of girls. As girls report higher levels of anxiety, the gender segregation of higher education graduates across fields is also higher. Similarly, as boys surpass girls in their sense of self-concept and efficacy towards math, higher education graduates tend to be more segregated. Note that religiosity is not significant when accounting for math anxiety and self-concept gender disparities (Columns 6 and 7) but it remains statistically significant at the 0.10 level when including self-efficacy (Column 8). Table 4.2 checks the robustness of these results by estimating Equations (4.3) and (4.4) using the ID at 2 digit-level as the LHS variable. The results are similar to those found using the ID at the broader level.

[18]I use the percentage of the total WVS respondents over the five waves used here who claim to belong to a specific religion.

Table 4.2: Country-level Gender Segregation (Narrow Classification)

Dependent variable: Dissimilarity index (2 digit-level)	Cultural Values			Math Beliefs		
	(1)	(2)	(3)	(4)	(5)	(6)
L4.Performance gap	-0.191	-0.042	-0.031	-0.004	0.016	-0.032
	(0.158)	(0.070)	(0.033)	(0.036)	(0.044)	(0.031)
L4.Fertility	-16.005*	-10.627**	-8.639***	-10.886***	-8.046***	-9.110***
	(8.866)	(4.764)	(2.650)	(3.298)	(2.324)	(2.858)
L4.GII	60.189					
	(61.692)					
L4.Gender Equality		-25.743				
		(22.314)				
L4.Religiosity			-0.195**	-0.024	-0.060	-0.155*
			(0.080)	(0.084)	(0.083)	(0.081)
Anxiety gap				0.477*		
				(0.233)		
Self-concept gap					0.274**	
					(0.108)	
Self-efficacy gap						-0.045
						(0.331)
No. of Obs.	179	195	136	128	128	128
No. of Groups	26	23	18	17	17	17
log-likelihood	-435.438	-479.668	-204.972	-188.434	-189.500	-193.537
Within R-squared	0.148	0.132	0.480	0.513	0.505	0.472

Country-level clustered standard errors in parentheses, * $p < .1$, ** $p < .05$, *** $p < .01$. Within-group estimates including time fixed-effects, constant terms not reported. Fourth period lagged explanatory variables except for variables of math beliefs. The models include the full set of controls but are not reported.

4.5.2 Field and subfield-level analyses

Thus far the estimates provide evidence that religiosity may partly matter to country-level horizontal gender segregation, and that gender gaps in math beliefs among young could be a more decisive factor of segregation in later education choices. This subsection seeks to identify whether religiosity and math beliefs matter to the level of gender segregation in specific fields or subfields. The models specified in Equation (4.5) employ the association index of either field or subfield i, in country c in year t as the LHS variable.

$$\begin{aligned} Ai_{ct} = \beta_0 + \beta_1 Religiosity_{c,t-4} + \beta_2 FieldWeight_{c,t-4} + X'_{c,t-4}\beta_i + \gamma_t + \alpha_c + u_{ct} \\ i = field(subfield); c = country; t = year \end{aligned} \tag{4.5}$$

where Ai_{ct} is the gender association of field or subfield i in country c and year t, with α_c and γ_t being country and time fixed-effects. $X_{c,t-4}$ is the same set of controls as described above. To alleviate potential omitted variables bias issues, I include the proportion of graduates in each field or subfield of study in the whole of higher education in the set of control variables ($FieldWeight_{ct}$). I first compute 9 models corresponding the 9 fields (broad classification). This step narrows down the focus and to estimate the impact of religiosity in specific subfields[19].

Before I review the results, it is worth noting that the Ai_{ct} is a continuous variable: positive values mean over-representation of women in the field, negative values mean over-representation of men and values close to zero mean gender neutrality. Thus, to accurately interpret a significant coefficient of the regressors, one needs to know ex-ante whether the field or subfield at stake is male-labelled or female-labelled. Positive coefficients associated with the regressors in female-dominated fields would imply a positive relation with gender segregation in that it means a perpetuation of females in female-dominated fields. Negative values for the same coefficients would imply a negative effect on gender segregation. In considering male-dominated fields, positive (negative) values associated with the regressors would imply a negative (positive) correlation with segregation. To ease the interpretation of field and subfield-level results, Tables 4.3 and 4.4 provide the average gender-labelling of each field or subfield, with "F" female-domination and "M" male-domination.

Table 4.3 shows that religiosity seems to be associated with lower gender segregation in specifically four fields of study, namely education, science, agriculture, and health and welfare. These findings might shed some light on the correlation between religiosity and lower horizontal gender segregation at national levels. All the models in Table 4.3 introduce the full set of controls of Equation (4.5), but I report the coefficients of religiosity, fertility and gender gaps in math beliefs as they are the main contribution of the paper.

[19]For the sake of space, all the models of the 23 subfields are not included here but they are available upon request.

Table 4.3: Field-level Gender Segregation

Dependent variable: Association Index (fields)								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Educ	Hum & Arts	Soc. Sci	Science	Eng.	Agri.	Health	Serv
Gender-label	F	F	F	M	M	M	F	M
PANEL A:								
L4.Fertility	-0.125	-0.166	0.024	-0.183	0.226	0.453	-0.085	-0.410
	(0.222)	(0.186)	(0.138)	(0.187)	(0.247)	(0.350)	(0.119)	(0.359)
L4.Religiosity	-0.016***	-0.001	0.002	0.012*	0.005	0.016**	-0.015**	0.005
	(0.005)	(0.005)	(0.005)	(0.006)	(0.007)	(0.007)	(0.006)	(0.004)
No. of Obs.	136	136	136	136	136	136	136	136
No. of Groups	18.000	18.000	18.000	18.000	18.000	18.000	18.000	18.000
log-likelihood	131.314	185.155	201.917	123.755	168.061	91.927	159.399	92.940
Within R-squared	0.305	0.304	0.228	0.276	0.473	0.272	0.240	0.267
PANEL B: Math Anxiety Gender Gaps								
Anxiety gap	0.031*	-0.013	-0.002	-0.044**	0.040***	0.008	0.039***	0.057**
	(0.015)	(0.016)	(0.011)	(0.018)	(0.014)	(0.034)	(0.012)	(0.023)
L4.Fertility	-0.230	-0.118	0.071	-0.121	0.089	0.325	-0.236	-0.537
	(0.218)	(0.145)	(0.149)	(0.211)	(0.202)	(0.385)	(0.154)	(0.347)

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Table 4.3: Field-level Gender Segregation

Dependent variable: Association Index (fields)								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Educ	Hum & Arts	Soc. Sci	Science	Eng.	Agri.	Health	Serv
Gender-label	F	F	F	M	M	M	F	M
L4.Religiosity	-0.007	-0.005	-0.001	0.001	0.021***	0.026**	-0.013***	0.015**
	(0.009)	(0.008)	(0.008)	(0.008)	(0.006)	(0.011)	(0.004)	(0.006)
log-likelihood	124.510	175.381	188.541	136.085	174.281	85.535	155.713	99.945
Within R-squared	0.317	0.338	0.198	0.425	0.498	0.271	0.327	0.342
PANEL C: Math Self-concept Gender Gaps								
Self-concept gap	0.015*	-0.004	0.006	-0.015*	-0.009	-0.005	0.005	0.051***
	(0.008)	(0.007)	(0.005)	(0.008)	(0.010)	(0.021)	(0.011)	(0.017)
L4.Fertility	-0.067	-0.179	0.088	-0.326*	0.211	0.344	-0.069	-0.119
	(0.202)	(0.185)	(0.164)	(0.185)	(0.195)	(0.365)	(0.132)	(0.291)
L4.Religiosity	-0.009	-0.003	0.002	0.007	0.007	0.023***	-0.019***	0.016***
	(0.007)	(0.007)	(0.007)	(0.006)	(0.009)	(0.006)	(0.006)	(0.005)
log-likelihood	123.322	174.441	189.128	131.181	165.998	85.529	149.416	106.066
Within R-squared	0.304	0.328	0.205	0.379	0.429	0.270	0.258	0.402
PANEL D: Math Self-efficacy Gender Gaps								
Self-efficacy gap	0.044	0.000	0.026	-0.069***	0.008	-0.020	0.009	-0.005

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Table 4.3: Field-level Gender Segregation

Dependent variable: Association Index (fields)								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Educ	Hum & Arts	Soc. Sci	Science	Eng.	Agri.	Health	Serv
Gender-label	F	F	F	M	M	M	F	M
	(0.028)	(0.028)	(0.025)	(0.021)	(0.028)	(0.042)	(0.024)	(0.050)
L4.Fertility	-0.266	-0.160	-0.025	-0.070	0.213	0.434	-0.122	-0.324
	(0.214)	(0.136)	(0.154)	(0.191)	(0.193)	(0.414)	(0.127)	(0.414)
L4.Religiosity	-0.013*	-0.001	0.001	0.009*	0.010	0.023***	-0.020***	-0.000
	(0.007)	(0.007)	(0.006)	(0.005)	(0.007)	(0.007)	(0.006)	(0.007)
log-likelihood	123.267	174.188	190.117	133.821	165.054	85.637	149.198	93.625
Within R-squared	0.303	0.325	0.217	0.404	0.420	0.272	0.255	0.274
N	128	128	128	128	128	128	128	128
No. of Groups	17	17	17	17	17	17	17	17

Country-level clustered standard errors in parentheses, * $p < .1$, ** $p < .05$, *** $p < .01$. Within-group estimates including time fixed-effects, constant terms not reported. Fourth period lagged explanatory variables except for variables of math beliefs. The models include the full set of controls but are not reported. Panels B-D include math beliefs and the number of clusters and observations are the same across fields. Educ (Education); Hum & Arts (Humanities and Arts); Soc. Sci (Social Sciences, Business and Law); Science (Science, Mathematics and Computing); Eng. (Engineering, Manufacturing and Construction); Agri. (Agriculture and Veterinary); Health (Health and Welfare); Serv. (Services). To ease the interpretation of the coefficients, behind the name of each field is the sample average gender label of M (male) and F (female), meaning whether the field is male-dominated or female-dominated respectively. Recall that the dependent variable is a continuous variable ranging negative values for male-dominated fields and positive values for female-dominated fields.

Models in Panel A (Table 4.3) exclude math beliefs. Fertility is not associated with a significant role in gender-labelling in any field. Religiosity is significantly associated with gender segregation in four out of the eight fields: religiosity enters with a negative coefficient in the models of female-dominated fields (education and health and welfare, Columns 1 and 7), and with a positive sign in male-dominated fields (science and agriculture, Columns 4 and 6). Hence, these estimates associate religiosity with lower segregation in these fields.

Panels B, C and D in Table 4.3 include gender gaps in math anxiety, self-concept and self-efficacy, respectively. Field-level estimates tend to corroborate that gender gaps in math beliefs are associated with horizontal gender segregation. Increasing these gender gaps is persistently associated with higher male-labelling in the field of science (Column 4), but their explanatory power varies across math beliefs. However, Column 5 in Panel B associates higher math anxiety gender gaps with lower male-labelled engineering. When gender gaps in math beliefs are accounted for, religiosity is still significantly associated with lower male-labelling in agriculture (Column 6) and female-labelling in health and welfare (Column 7). That is, the negative association between religiosity and gender segregation is also found in field-level estimates.

The final step in this paper is to regress Equation (4.5) against the A_{ict} at subfield level. My previous results suggest that religiosity and gender gaps might be important for the gender-labelling of the fields of agriculture, health and welfare, and to a lesser extent education and science (Table 4.3). Table 4.4 focus on the subfields that make up these specific fields: Agriculture is divided into *agriculture, forestry and fishery* and *veterinary* studies. Health and welfare is divided into *health* and *social services*. Science is divided into *life science*, *physical science*, *mathematics and statistics* and *computing*[20].

Panel A (Table 4.4) associates religiosity with lower male-labelling of *mathematics and statistics* (Column 3) and *agriculture, forestry and fishery* (Column 5), and with lower female-labelling of *social services* (Column 8). This corroborates my previous finding: religiosity is associate with lower gender segregation in higher education. When accounting for math beliefs gender gaps (Panels B, C and D), only the link between religiosity and *social services* remains significant at the 0.01 level. The estimates in Panel B (Table 4.4) provide little evidence of a link between anxiety gaps and segregation by subfields, whereas Panel C significantly associates gender disparities in math self-concept with greater segregation in *computing* and *veterinary* studies. To the contrary, Panel D associates math self-efficacy gaps with lower segregation in the two subfields of agriculture.

[20]Recall that education stands alone on the basis of ISCED1997 and it is dropped from the subfield-level analysis to avoid repetition.

4.6 Conclusion

Persisting levels of gender segregation across fields of study in Western countries seem at odds with the increase in female participation in higher education. This observation is particularly puzzling against the backdrop of affirmative action, anti-discrimination policies, and gender-egalitarian ideals in developed countries. The literature highlights individual factors (gender gaps in preferences and foreseeing family obligations) and external factors (economic structure, institutions, discrimination) as causes of gender segregation. This paper studies whether cultural values, in particular gender equality and religion, play a role in horizontal gender segregation in higher education.

I construct a panel dataset with information on gender segregation indices at national level, at 9-field level and at 23-subfield level for 26 OECD countries for 1998-2012. I link this data with two focal cultural traits: Gender equality, measured by either the Gender Inequality Index (UNDP) or the Gender Equality measure (IDEA), and religiosity, measured by World Value Survey (WVS) data. I propose fixed-effects models that control for potential segregative factors such as economic structural change, labour market and educational systems features. The estimates fail to associate gender (in)equality measures with a significant role in horizontal gender segregation. By contrast, religiosity is significantly associated with lower levels of horizontal gender segregation.

I augment the models to control for aggregate-level gender gaps in math beliefs of the youth. Using two waves of data taken from PISA surveys, I find a contemporaneous association between gender gaps in anxiety, self-concept and self-efficacy with higher gender segregation of graduates across fields of study. Field and subfield-levels analyses pinpoint to a robust association between religiosity and lower segregation levels in the fields of agriculture and health and welfare, and more specifically in the subfield of *social services*.

From a policy viewpoint, the role of religiosity may be controversial. The results on gender gaps in math beliefs, by its part, indicate that efforts to close gaps between boys and girls might enhance a more gender-equal distribution across fields of study in higher education. Nevertheless, it should be stressed that the findings above are based on macro-level data on segregation, and should be taken with caution. Two natural ways to extend this paper would be first to scrutinize whether there is any link between cultural traits and vertical segregation, i.e. gender segregation at levels of educational attainment; and second to consider the gender gaps in reading and science ability perceptions of young people.

Table 4.4: Subfield-level Segregation (Selected Subfields)

Dependent variable: Association Index (subfields)								
	Science				Agriculture		Health & Welfare	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Life S.	Phy S.	Math.	Comp.	Agri.	Vet.	Health	Soc. Serv.
Gender label	F	M	M	M	M	F	F	F
PANEL A:								
L4.Fertility	-0.005	0.009	0.144	-0.338	0.389	0.322	0.234**	-0.425
	(0.200)	(0.171)	(0.224)	(0.346)	(0.493)	(0.452)	(0.107)	(0.330)
L4.Religiosity	0.009	0.001	0.024**	0.008	0.018**	0.015	-0.008	-0.034***
	(0.007)	(0.006)	(0.011)	(0.009)	(0.007)	(0.020)	(0.006)	(0.010)
No. of Obs.	136	136	136	136	136	136	136	136
No. of Groups	18	18	18	18	18	18	18	18
log-likelihood	109.827	143.737	87.493	88.301	104.287	2.154	163.987	78.003
Within R-squared	0.309	0.210	0.239	0.731	0.262	0.370	0.332	0.476
PANEL B: Math Anxiety Gender Gaps								
Anxiety gap	-0.042	0.001	-0.012	-0.023	0.009	-0.030	0.027*	0.029
	(0.025)	(0.010)	(0.032)	(0.024)	(0.019)	(0.051)	(0.013)	(0.022)
L4.Fertility	0.168	-0.072	0.151	-0.123	0.180	0.477	0.123	-0.727*

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Table 4.4: Subfield-level Segregation (Selected Subfields)

Dependent variable: Association Index (subfields)								
	Science				Agriculture		Health & Welfare	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Life S.	Phy S.	Math.	Comp.	Agri.	Vet.	Health	Soc. Serv.
Gender label	F	M	M	M	M	F	F	F
	(0.286)	(0.190)	(0.210)	(0.316)	(0.454)	(0.503)	(0.124)	(0.416)
L4.Religiosity	-0.006	0.004	0.022	-0.001	0.018*	0.027	-0.008	-0.043***
	(0.007)	(0.006)	(0.015)	(0.014)	(0.010)	(0.016)	(0.004)	(0.011)
log-likelihood	104.780	137.053	81.975	89.082	102.642	12.700	159.604	77.704
Within R-squared	0.340	0.240	0.185	0.751	0.249	0.453	0.379	0.528
PANEL C: Math Self-concept Gender Gaps								
Self-concept gap	0.017	0.002	-0.019	-0.031***	-0.020	0.044***	-0.006	0.016
	(0.014)	(0.010)	(0.014)	(0.010)	(0.012)	(0.012)	(0.012)	(0.010)
L4.Fertility	0.109	-0.063	0.030	-0.324	0.176	0.568	0.170	-0.556
	(0.257)	(0.180)	(0.147)	(0.309)	(0.440)	(0.334)	(0.101)	(0.356)
L4.Religiosity	0.011	0.004	0.018	-0.005	0.011	0.049**	-0.016**	-0.045***
	(0.008)	(0.004)	(0.015)	(0.010)	(0.006)	(0.017)	(0.007)	(0.009)
log-likelihood	102.345	137.080	83.245	92.443	104.165	14.792	156.630	77.316

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Table 4.4: Subfield-level Segregation (Selected Subfields)

Dependent variable: Association Index (subfields)								
	Science				Agriculture		Health & Welfare	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Life S.	Phy S.	Math.	Comp.	Agri.	Vet.	Health	Soc. Serv.
Gender label	F	M	M	M	M	F	F	F
Within R-squared	0.314	0.241	0.201	0.764	0.266	0.471	0.350	0.525
PANEL D: Math Self-efficacy Gender Gaps								
Self-efficacy gap	0.021	0.013	0.070	-0.040	0.061**	-0.124**	0.024	-0.063
	(0.036)	(0.023)	(0.043)	(0.030)	(0.025)	(0.047)	(0.017)	(0.044)
L4.Fertility	-0.040	-0.111	-0.139	-0.076	-0.016	0.812	0.103	-0.438
	(0.226)	(0.200)	(0.160)	(0.348)	(0.436)	(0.532)	(0.104)	(0.330)
L4.Religiosity	0.006	0.004	0.028**	0.003	0.018**	0.030*	-0.012*	-0.054***
	(0.007)	(0.005)	(0.012)	(0.011)	(0.006)	(0.016)	(0.006)	(0.008)
log-likelihood	101.141	137.232	84.019	88.948	104.892	14.668	157.020	78.043
Within R-squared	0.301	0.243	0.211	0.751	0.275	0.470	0.354	0.531
No. of Obs.	128	128	128	128	128	128	128	128
No. of Groups	17	17	17	17	17	17	17	17

Country-level clustered standard errors in parentheses, * $p < .1$, ** $p < .05$, *** $p < .01$. Within-group estimates including time fixed-effects, constant terms not reported. Fourth period lagged explanatory variables except for variables of math beliefs. The models include the full set of controls but are not reported. Panels B-D include math beliefs and the number of clusters and observations are the same across subfields. Life S. (Life Science); Phys. S. (Physical Science); Maths. (Mathematics and statistics); Comp. (Computing); Agri. (Agriculture, forestry and fishery); Vet. (Veterinary); Soc. Serv. (Social Services). To ease the interpretation of the coefficients, behind the name of each subfield is the sample average gender label of M (male) and F (female), meaning whether the subfield is male-dominated or female-dominated respectively. Recall that the dependent variable is a continuous variable ranging negative values for male-dominated fields and positive values for female-dominated fields.

4.7 Appendix A

Table A4.1: ISCED1997 Classification

1 digit-level	2 digit-level
Education	Teacher training and education science
Humanities and arts	Arts
	Humanities
Social Sciences, business and law	Social and behavioural science
	Journalism and information
	Business and administration
	Law
Science	Life science
	Physical science
	Mathematics and statistics
	Computing
Engineering, manufacturing and construction	Engineering and engineering trades
	Manufacturing and processing
	Architecture and building
Agriculture	Agriculture, forestry and fishery
	Veterinary
Health and welfare	Health
	Social services
Services	Personal services
	Transport services
	Environmental protection
	Security services
Not known or unspecified	Not known or unspecified

Table A4.2: Summary Statistics

	Mean	**Std. Dev.**	**Min.**	**Max.**	**N**
Gender Inequality Index	0.148	0.068	0.051	0.564	215
Gender Equality (IDEA)	0.789	0.123	0.31	1	196
Religiosity	22.138	15.799	7.532	75.78	168
% Jew	0.746	1.534	0.052	7.378	168
% Catholic	36.032	29.524	0.157	94.400	168
% Protestant	22.39	23.451	0.157	84.117	168
% Muslim	7.58	23.584	0.066	98.886	168
Pop. density	142.32	132.518	2.734	505.562	218
Fem. Labour Force	44.879	2.65	29.186	48.452	218
% Services	67.321	7.36	49.171	82.964	218
% Prof. Female	49.424	7.415	30.51	64.707	218
Size Grads	11.569	1.471	5.823	15.012	218
Diversification	19.1	16.042	0.04	60.004	218
% Graduates Fem.	57.254	5.673	25.391	67.5	218
Performance gap	4.984	7.413	-21.05	21.36	218
Divorce rate	2.167	0.687	0.4	3.8	218
Fertility	1.594	0.29	1.076	2.23	218
Marri. Age (females)	28.339	2.048	23.3	32.8	218
Field weight	0.118	0.097	0.000	0.463	970
Subfield weight	0.045	0.053	0.000	0.32	2556
Anxiety gap	5.32	4.726	-5.042	14.174	50
Self-concept gap	21.51	9.658	4.493	41.84	50
Self-efficacy gap	9.14	2.899	3.159	15.783	50

Sample of Countries (Columns 1, Table 1): Austria, Belgium, Canada, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Korea, Rep., Luxembourg, Netherlands, Norway, Poland, Portugal, Slovak Republic, Spain, Sweden, Switzerland, Turkey, United Kingdom, United States.

Sample of Countries (Data on WVS and math beliefs): Canada, Czech Republic, Finland, France, Germany, Hungary, Italy, Korea, Rep., Netherlands, Norway, Poland, Slovak Republic, Spain, Sweden, Switzerland, Turkey, United Kingdom (not in PISA), United States.

Table A4.3: Data Sources

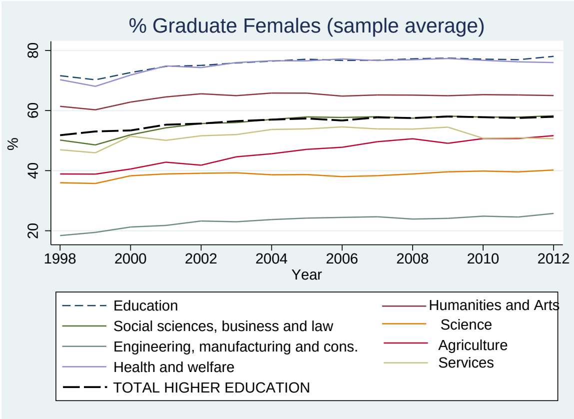
Variable	Description	Data Source
Population Density	Number of people per square kilometre	World Bank data
Female Labour Force	Female labour force participation rate	ILOSTAT database
% Service Economy	Share of employment in service sector to total employment using the International Standard Classification of Occupations (ISCO-88)	"
% Prof. Female	Share of females in the occupational status of "professionals" (ISCO-88: group 2)	"
Size Grads	Share of total graduates in higher education to total population in percentages	OECD Education Database, World Bank
% Graduates Fem.	Share of females in total graduates in higher education	OECD Education Database
Performance gap	Female to male ratio of mean scores in PISA, TIMSS and PIRLS international tests from Quality of Education Database	Altinok et al. (2014)
Religiosity	Share of WVS respondents who say that *"God is important in my life"* equal to 10 on a 0 to 10 scale that	World Value Survey
Gender Inequality Index (GII)	This measure reflects gender-based disadvantage regarding reproductive health, empowerment and the labour market. Higher values mean greater gender inequality.	United Nations Development Program
Gender Equality (GE)	Measure of gender equality in participation in civil society organizations and politics and education (Skaaning, 2017)	International IDEA
Divorce rate	Number of divorces during the year per 1,000 people	OECD Family Database
Fertility	Total number of births per woman	World Bank

Table A4.4: Cross-correlation Table

	PD	Ser	Prof	FL	Grad	Diver	GFem	PG	Fert	Div	Cath	Prot	Mus	Jew	Rel	GII	GE
Ser	0.017																
Prof	-0.281	-0.367															
FL	-0.161	0.443	0.317														
Grad	0.066	-0.048	0.282	0.232													
Diver	0.242	0.082	-0.420	-0.333	0.044												
GFem	-0.279	0.064	0.491	0.471	0.295	-0.519											
PG	0.354	0.073	-0.216	-0.128	-0.314	0.300	-0.280										
Fert	-0.281	0.409	-0.219	-0.145	0.100	0.069	-0.028	-0.242									
Div	0.131	0.217	-0.082	0.428	-0.014	0.124	0.016	-0.066	-0.025								
Cath	0.001	-0.423	0.482	0.081	0.173	-0.230	0.156	0.178	-0.619	-0.417							
Prot	-0.184	0.415	-0.204	0.398	0.025	-0.096	0.137	-0.130	0.186	0.276	-0.458						
Mus	-0.095	-0.651	-0.389	-0.790	-0.287	0.263	-0.539	-0.133	0.576	-0.446	-0.302	-0.303					
Jew	-0.330	0.277	0.333	0.228	-0.001	-0.154	0.171	0.107	0.297	0.505	-0.118	0.379	-0.114				
Rel	-0.243	-0.321	0.169	-0.560	0.107	0.040	-0.252	-0.164	0.389	-0.323	0.099	-0.311	0.684	0.031			
GII	-0.139	-0.509	-0.057	-0.747	-0.109	0.137	-0.266	-0.094	0.249	-0.244	-0.037	-0.330	0.813	0.018	0.765		
GE	-0.131	0.665	0.076	0.748	0.023	-0.221	0.443	0.057	0.003	0.327	0.012	0.452	-0.598	0.167	-0.633	-0.817	
Anx	-0.108	0.323	-0.388	0.209	-0.266	0.098	-0.090	0.009	0.122	0.110	-0.177	0.340	-0.376	0.140	-0.375	-0.235	0.399
Con	-0.002	0.285	-0.511	0.120	-0.378	0.142	-0.257	0.184	0.080	0.169	-0.231	0.305	-0.152	0.268	-0.099	-0.150	0.244
Effi	0.212	0.451	-0.509	0.247	-0.350	0.010	-0.163	0.315	0.147	0.138	-0.439	0.527	-0.322	0.005	-0.561	-0.459	0.489

PD (Pop. density); Ser (% Services); Prof (% Prof. Fem.); FL (Fem. Labour Force); Grad (Grads Size); Diver. (Diversif.); GFem (% Grads Female); PG (Performance gap); Fert (Fertility); Div (Divorce); Cath (% Catholic); Prot (% Protest.); Mus (% Muslims); Jew (% Jew); Rel (Religiosity); GII; GE.

Figure A4.1: Trend in Proportion of Female Graduates



"Not known or unspecified" (NKOU) is not displayed in the graph

4.8 Appendix B

Figure B4.1: Gender-related Social Norms

Country averages for 1998-2012

4.9 Appendix C

Table C4.1: Math Anxiety PISA Questions

Question	Boys	Girls	Girls - Boys
I often worry that it will be difficult for me in mathematics classes	56.37	62.94	7.45
I get very tense when I have to do mathematics homework	28.05	31.99	3.94
I get very nervous doing mathematics problems	28.47	32.24	3.77
I feel helpless when doing a mathematics problem	29.25	34.99	5.74
I worry that I will get poor (grades) in mathematics	57.79	64.41	6.61

Table C4.2: Math Self-Concept PISA Questions

Question	Boys	Girls	Boys - Girls
I am just not good at mathematics (strongly disagree or disagree)	63.26	52.27	11.11
I get good grades in mathematics	60.20	54.60	5.64
I learn mathematics quickly	58.69	22.92	40.10
I have always believed that mathematics is one of my best subjects	43.56	15.86	29.76
In my mathematics class, I understand even the most difficult work	42.76	15.22	29.03

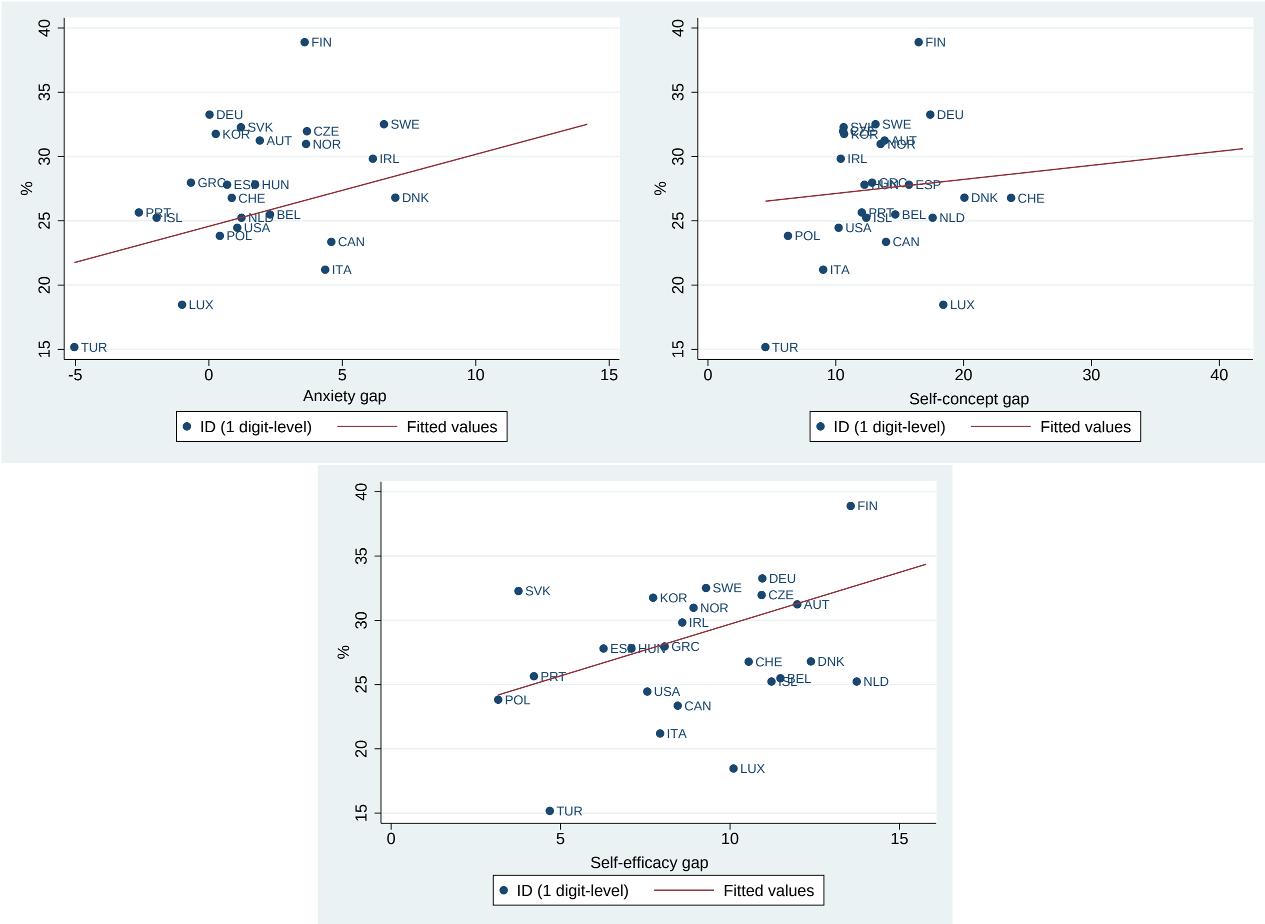
Table C4.3: Math Self-Efficacy PISA Questions

Question	Boys	Girls	Boys - Girls
Using a train timetable to work out how long it would take to get from one place to another	82.99	77.67	5.31
Calculating how much cheaper a TV would be after a 30% discount	84.32	75.98	8.35
Calculating how many square metres of tiles you need to cover a floor	75.77	61.43	14.34
Understanding graphs presented in newspapers	81.15	76.27	4.88
Solving an equation like 3x+5=17	83.8	85.2	-1.40
Finding the actual distance between two places on a map with a 1:10 000 scale	67.44	48.36	19.08
Solving an equation like 2(x+3)=(x+3)(x-3)	70.79	71.65	-.86
Calculating the petrol-consumption rate of a car	68.25	44.82	23.43

Table C4.4: Cross-correlation Table

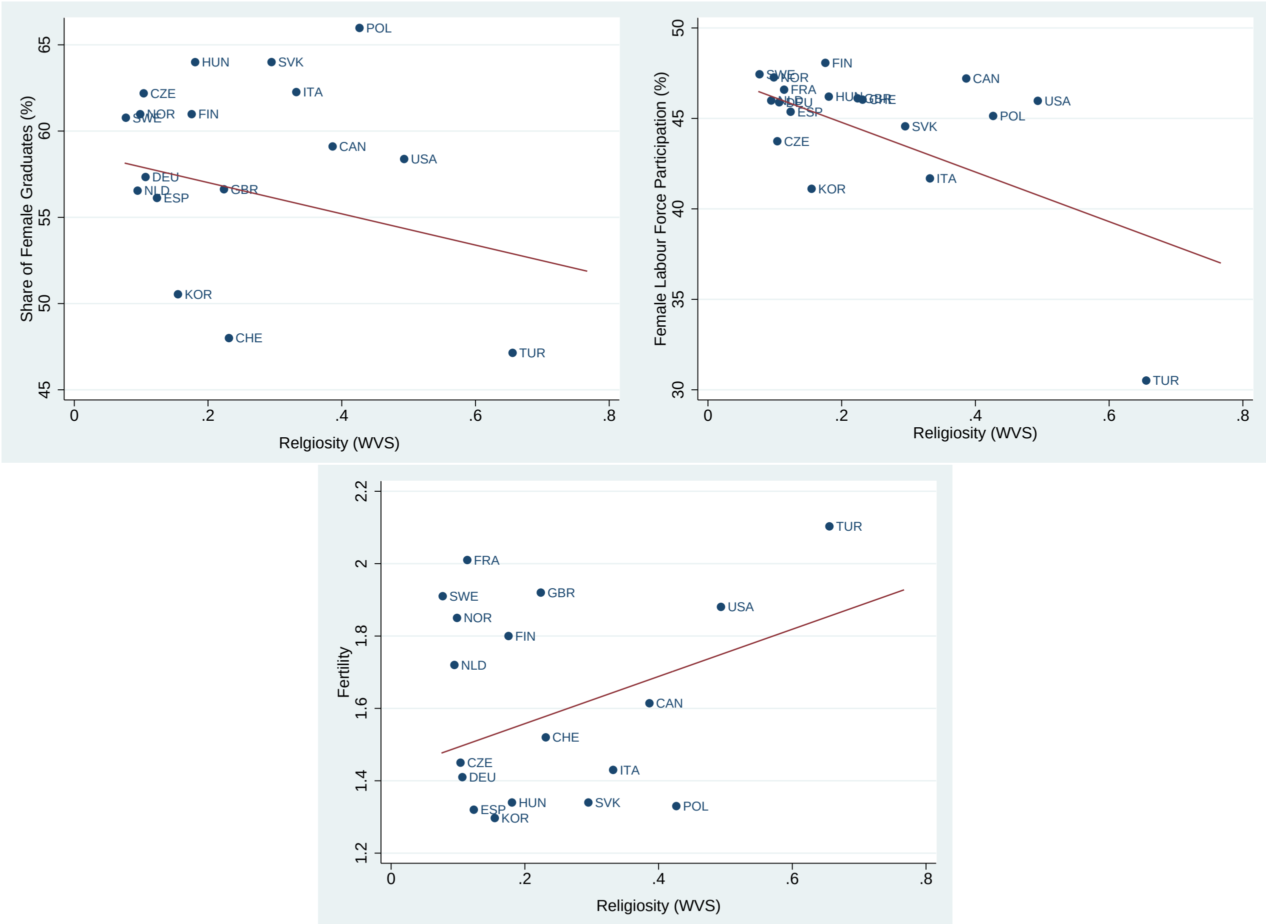
Variables	Anxiety gap	Self-concept gap
Self-concept gap	0.816	
Self-efficacy gap	0.388	0.383

Figure C4.1: Gender Segregation and Self-reported Math Beliefs



Dissimilarity index at 1 digit-level and gender gaps in math beliefs in 2012

Figure C4.2: Women in the Labour Market and Higher Education and Religiosity



Female participation in the labour market and higher education, fertility and religiosity in 2012

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