Artigos

Empresas Estrangeiras e Capital Humano nos Serviços Intensivos em Conhecimento*

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resumo

O efeito das empresas estrangeiras na economia receptora poderá ocorrer através do mercado de trabalho, contribuindo aquelas para o desenvolvimento do capital humano. Este artigo investiga se as empresas estrangeiras contribuíram positivamente para o desenvolvimento do capital humano, analisando o sector dos serviços intensivos em conhecimento em Portugal. A análise empírica baseia-se num painel de empresas no período de 2000 a 2006 construido com dados dos *Quadros de Pessoal*. Verifica-se que as empresas com participação estrangeira no capital social apresentam, tudo o resto constante, uma maior intensidade de capital humano do que as empresas nacionais.

résumé / abstract

L'effet des entreprises étrangères sur l'économie du pays d'implantation peut se produire via le marché du travail en contribuant au développement du capital humain de l'économie d'implantation. Cet article étudie la contribution positive des entreprises étrangères au développement du capital humain, en analysant le secteur des sociétes de services spécialisées dans la connaissance (les «Knowledge Intensive Business Services») au Portugal. L'étude se base sur un panel de données au niveau des entreprises pour la période de 2000 à 2006. La base de données utilisée est *Quadros de Pessoal*. Les résultats mettent en évidence que les entreprises ayant un capital étranger présentent, un capital humain plus qualifié que les entreprises nationales

The effect of foreign firms on host economies may occur through labour market, leading to the development of human capital. This paper investigates whether foreign firms contributed in a positive way to the development of human capital, looking in detail at the knowledge intensive services in Portugal. The study is based on panel data at the firm level for the period 2000-2006 using the *Quadros de Pessoal* dataset. The results show that firms with foreign capital have higher human capital intensity than domestic firms.

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1. Introdução

As multinacionais tornaram-se nas últimas décadas agentes económicos de grande destaque, centrais no processo de crescimento e modernização das economias. O efeito das multinacionais ocorre, por um lado, pela transferência de tecnologia, contribuindo para um *upgrade* tecnológico da economia receptora (Blomström e Kokko, 1998; Baldwin *et al.*, 2005). O seu efeito poderá ocorrer também de forma indirecta, nomeadamente através do mercado de trabalho, contribuindo aquelas para o desenvolvimento do capital humano.

A literatura na temática (ex. Slaughter, 2002 e Slaughter e Blonigen, 2001; Lunati and O'Connor 1999; Blomström e Kokko, 1998; 2003; Larudee e Koechlin, 1999; Lipsey, 2004; Kapstein, 2002) revela que a relação entre capital humano e investimento directo estrangeiro é bidireccional[1]. Por um lado, o nível de capital humano é um factor de atracção de Investimento Directo Estrangeiro (IDE). Por outro lado, a presença estrangeira pode contribuir para o desenvolvimento do capital humano.

Este artigo analisa a hipótese de as empresas estrangeiras contribuírem positivamente para o desenvolvimento do capital humano. Especificamente, o artigo testa se as empresas estrangeiras apresentam, comparativamente com as nacionais, maior intensidade de capital humano, medido pela percentagem de trabalhadores que detêm determinados níveis de qualificações ou habilitações, na linha do adoptado, por exemplo, por Bouquet *et al.* (2004). Este artigo incide sobre o sector dos serviços intensivos em conhecimento (SIC), que tem sido descurado pela literatura nesta temática, apesar da sua importância em termos de produto, emprego e investimento (UNCTAD, 2004).

O sector dos serviços intensivos em conhecimento é composto por empresas que vendem serviços para outras empresas em que o conhecimento (trabalho qualificado, e conhecimento incorporado quer nas pessoas quer em tecnologia) e a informação são os principais componentes. O conhecimento é utilizado para satisfazer uma necessidade específica do cliente (Miles, 2005; Tomlinson, 2002).

Em 2005, os SIC representavam 33,3% do emprego na Europa (EU-25). Entre 2000 e 2005 os serviços de alta intensidade tecnológica cresceram a uma taxa anual de 2,7%, e Portugal (9,9%) foi dos países que registou maiores taxas de crescimento (EUROSTAT, 2007). Assistimos também a um crescimento significativo do investimento directo estrangeiro neste sector (EUROSTAT, 2004). O crescimento do *outsourcing*, a procura crescente pelas tecnologias de informação (TIC) criaram a oportunidade para o aparecimento de serviços especializados. Por último, algumas mudanças que ocorreram no mercado de trabalho, em particular o aparecimento de certo tipo de qualificações escassas e que são melhor remuneradas nos SIC, e o facto de um número cada vez maior de pessoas preferir trabalhar em actividades que proporcionam maiores oportunidades de aprendizagem (European Foundation, 2005), têm contribuído para o crescimento deste sector.

O sector engloba um conjunto de actividades determinantes no crescimento e competitividade das economias e regiões (Miles *et al.*, 1996; Tomlinson, 2002; Miles, 2005; Harrington e Daniels, 2006; Bishop, 2008). Os serviços aí incluídos são tidos como elementos fundamentais na criação e comercialização de novos produtos e novos processos e desenvolvimento do capital humano (Tomlinson, 2002; OECD, 2006; Quevedo e Verdú, 2008).

O estudo empírico é aplicado à economia portuguesa utilizando a base de dados dos *Quadros de Pessoal*, extremamente representativa do sector privado da economia portuguesa (Almeida, 2004). No contexto dos SIC, procura-se testar as seguintes hipóteses:

1 O Investimento directo estrangeiro define-se por ser um investimento de longo prazo em que o investidor estrangeiro tem uma influência dominante na gestão da empresa (UNCTAD, 2005). De acordo com a OCDE (1999) para que esta influência exista o investidor precisa de deter pelo menos 10% do capital social da empresa.

1.º) Se as empresas estrangeiras possuem uma maior intensidade de capital humano face às suas congéneres nacionais;

2.º) Se a percentagem que o investidor estrangeiro detém no capital social é relevante em termos de comportamento diferenciador no que respeita à intensidade do capital humano.

O artigo encontra-se estruturado em quatro partes. Na segunda parte procede-se ao enquadramento teórico sobre a relação IDE, sector de serviços intensivos em conhecimento e desenvolvimento do capital humano. Os resultados empíricos são apresentados na terceira secção. Por último, na quarta secção apresentam-se os principais contributos e conclusões.

2. IDE, SIC e Capital Humano

De acordo com a UNCTAD (2009), o peso dos serviços no stock mundial de investimento directo estrangeiro (IDE) passou de 49% em 1990 para 64% em 2007, apresentando o IDE neste sector uma taxa de crescimento superior à de outros sectores. Existem três razões que explicam este crescimento. A primeira tem a ver com o crescimento da importância dos serviços em termos de emprego e de valor acrescentado. A segunda razão tem a ver com o carácter não transaccionável da maior parte dos serviços, o que significa que precisam de ser produzidos e consumidos no mesmo local (Bouquet *et al.*, 2004). A terceira razão tem a ver com a liberalização das políticas em relação ao IDE nos serviços face ao reconhecimento dos seus efeitos positivos, nomeadamente no acesso a tecnologias mais avançadas (Blomström e Kokko, 2003; Wang *et al.*, 2002; EUROSTAT, 2004).

Apesar da significativa presença estrangeira no sector dos serviços, e deste nas economias, a grande maioria dos estudos que analisa os efeitos do IDE sobre o capital humano foca na manufactura. Apesar de algumas especificidades, estes estudos permitem-nos compreender a forma como o IDE neste sector poderá contribuir para o desenvolvimento do capital humano (Boddewyn *et al.*, 1986; Dunning, 1989).

Uma das primeiras condições para a existência de IDE consiste na existência de falhas de mercado. Para que as empresas realizem IDE estas devem possuir algumas vantagens próprias que lhes permitam competir com sucesso num ambiente hostil (Hymer, 1976; Dunning, 1977). As vantagens das empresas estrangeiras face às domésticas podem decorrer de conhecimentos (como capital humano, tecnologia, vantagens organizacionais) ou estar relacionadas com a dimensão e capacidade produtiva. Nos serviços, estas vantagens são maioritariamente elementos intangíveis (Bouquet *et al.* 2004; UNCTAD, 2004), centradas no conhecimento (por exemplo sobre clientes, padrões de consumo, software e hardware), capacidade e organização das actividades, economias de escala e gama. A internacionalização via IDE permite às empresas explorar as suas vantagens internacionalmente da melhor forma, ao reduzir a probabilidade de *spillover* do conhecimento e os custos de transacção, protegendo ao mesmo tempo a qualidade do produto/serviço prestado e tornando possível um maior conhecimento do mercado (Boddewyn *et al.*, 1986; Dunning, 1989).

A capacidade de uma região atrair IDE nos serviços está intimamente relacionada com a dimensão do mercado e a liberalização, boa rede de infra-estruturas de transporte e de comunicação e informação, assim como também com a disponibilidade de recursos (instituições e recursos humanos) qualificados. Também, ou ainda mais, nos serviços, a relação entre capital humano e IDE é bidireccional (Kapstein, 2002). Por um lado, o nível de capital humano é um factor de atracção de IDE. Por outro lado, a presença estrangeira pode contribuir para o desenvolvimento do capital humano (Blomström e Kokko, 2003; Gorg e Eric, 2005).

Os efeitos da presença estrangeira no mercado de trabalho podem ser analisados no âmbito de um modelo concorrencial de procura e oferta de trabalho qualificado, modelo em que as curvas da procura e oferta têm as inclinações habituais (Slaughter e Blonigen, 2001)[2].

2 As multinacionais podem influenciar a oferta de qualificações a três níveis: educação (através do financiamento de estudos, ex. bolsas de estudo, ou pela criação de escolas de negócios), formação interna

Neste artigo consideramos a influência da presença estrangeira ao nível da procura de trabalho qualificado. Essa influência pode ocorrer de três formas. A primeira resulta da transferência das vantagens específicas da multinacional (tecnologia em forma de capital ou conhecimento) para as filiais, a qual poderá implicar procura de trabalhadores qualificados para a utilização eficaz dessa tecnologia (Slaughter, 2002). A segunda é através dos efeitos *spillovers*. Os conhecimentos que as empresas filiais receberam da empresa mãe podem difundir-se pela economia receptora, pelo que vão ser necessários mais trabalhadores qualificados nas empresas que por contágio começam a utilizar essa tecnologia. Por último, a presença estrangeira pode contribuir para o aumento da procura de trabalho qualificado através dos investimentos em capital (Slaughter e Blonigen, 2001). O aumento do capital físico está associado a economias de escala que, para serem aproveitadas, necessitam de mercado com alguma dimensão. Para o conseguirem, precisam, por vezes, de políticas de marketing e de publicidade avançadas e trabalhadores devidamente qualificados para as levarem a cabo (Lunati e O'Connor, 1999).

Entre outros, os estudos de Wang *et al.* (2002), Narula e Marin (2003), Blomström e Kokko (2003), Barbosa (2007) e Siegel *et al.* (2005) revelam a maior intensidade de trabalhadores qualificados entre empresas estrangeiras. Outros estudos levantam algumas dúvidas sobre a relação, pois apesar de demonstrarem uma maior intensidade de capital humano, as multinacionais podem não ter um efeito significativo sobre a procura de trabalhadores qualificados. Por exemplo, Almeida (2004) revela que existiu um efeito selecção na década de 90 em Portugal, que o autor designou de efeito *cherry pick up*; os investidores estrangeiros adquiriram empresas nacionais que já possuíam trabalhadores qualificados.

As motivações dos investidores determinam, em grande medida, o tipo de procura de mão-de-obra por parte das empresas estrangeiras. Os investimentos orientados para a exploração de recursos naturais são intensivos em capital, necessitando de pouco trabalho qualificado (Te Velde, 2005). Se o objectivo do investimento for explorar a dimensão do mercado ou evitar custos de transporte elevados, ou porque é importante estar perto do cliente (Bergman, 2006), as filiais investem pouco na qualificação da mão-de-obra e em formação. Já no investimento orientado para a racionalização de custos, a existência de mão-de-obra barata e não qualificada é um factor importante (Te Velde e Morrissey, 2001, 2004). Por fim, o investimento motivado pela procura de activos estratégicos, caracteriza-se pela criação de filiais que usam tecnologias avançadas e desenvolvem actividades de inovação. Como tal, é de esperar que seja o tipo de investimento em que haja mais procura por trabalhadores qualificados e investimento em formação (Te Velde, 2005).

Para além das motivações dos investidores, outros factores influenciam o efeito do IDE sobre o emprego. Existem diferenças entre sectores, sendo de esperar que o IDE nos serviços tenha maior efeito sobre o emprego qualificado (Blomström e Kokko, 2003; UNCTAD, 2004). Esta suposição decorre de dois aspectos concretos. Enquanto que na indústria é possível a divisão do processo produtivo em fases, separando-se geograficamente as que necessitam de trabalho menos qualificado das que necessitam de trabalho mais qualificado, nos serviços esta separação é mais difícil. Por outro lado, no IDE nos serviços predomina a transferência de tecnologia no sentido de conhecimento (Boddewyn *et al.*, 1986; Bouquet *et al.*, 2004; UNCTAD, 2004), muitas vezes associado à utilização de equipamento sofisticado, pelo que a experiência e habilitações dos trabalhadores (conjugados com a implementação de programas de educação e formação específica) são factores importantes para o sucesso da transferência das práticas (UNCTAD, 2004). Com base na revisão de literatura exposta, espera-se que as empresas estrangeiras nos sectores intensivos em conhecimento tenham um comportamento diferenciado em termos de capital humano, isto é, que empreguem uma força de trabalho com mais habilitações e qualificações.

informal (*learning by doing*) ou formação interna formal (Slaughter, 2002; Slaughter e Blonigen, 2001; Kapstein, 2002; Blomström e Kokko, 2003; Gorg e Strobl, 2005; TeVelde e Xenogiani, 2007; Zheng *et al.*, 2007).

3. Análise Empírica

3.1. A base de dados

Os dados utilizados neste estudo são oriundos da base de dados dos *Quadros de Pessoal*, que contém informação sobre empresas, estabelecimentos e trabalhadores para a quase totalidade dos sectores da economia portuguesa desde 1982.

Com base no número de identificação das empresas, construiu-se uma base de dados em painel para as empresas pertencentes ao sector dos SIC, para o período de 2000 a 2006 (excepto 2001)[3]. A amostra inclui 306413 observações a que corresponde, em média, cerca de 51068 empresas por ano.

Seguindo a classificação do EUROSTAT, o sector SIC engloba actividades com elevada intensidade tecnológica (medida pelas despesas de I&D); actividades fortemente utilizadoras dessa tecnologia; actividades intensivas em conhecimento (medida pelas qualificações dos trabalhadores); e as actividades de educação, saúde[4], as actividades recreativas e de lazer e alguns serviços de transporte. Nesta linha, o sector dos serviços encontra-se dividido em dois grandes grupos: serviços intensivos em conhecimento e serviços com menor intensidade de conhecimento.

Como se pode observar pela leitura da Tabela 1, o peso dos SIC no total dos sectores tem vindo a crescer ao longo do período considerado, quer em termos de número de empresas, emprego ou volume de vendas. Em 2006 eram responsáveis por 26% do emprego total no sector privado da economia Portuguesa e por 25% do volume total de vendas.

TABELA 1 – Evolução do número de empresas, emprego e vendas nos SIC e total dos sectores – 2000, 2003 e 2006

	2000	2003	2006
Serviços intensivos em conhecimento			
N.º empresas	31617	50003	63975
Emprego	561733	646070	806237
Volume de vendas*	36047,18	67985,97	68595,60
Vendas médias por empresa	1,14	1,40	1,07
Todos os sectores			
N.º empresas	266853	305843	343953
Emprego	2699609	2848286	3099513
Volume de vendas*	233486,8	260936,9	274456,1
Vendas médias por empresa	0,87	0,85	0,80
Valores percentuais dos SIC em relação ao total dos sectores (%)			
Empresas	11,8	16,3	18,6
Emprego	20,8	22,7	26,0
Vendas	15,4	26,1	25,0

Fonte: *Quadros de Pessoal* e cálculos dos autores.
* Valores em milhões de euros, a preços constantes de 2000.

3 Não há dados disponíveis para os trabalhadores para o ano de 2001.
4 Pois são actividades intensivas em trabalho qualificado (Bishop, 2008).

Neste estudo designam-se por empresas estrangeiras (EE) aquelas empresas em que mais de 50% do capital social é detido por investidores estrangeiros; designam-se por empresas participadas (EP) aquelas empresas cuja participação estrangeira no capital social é positiva mas não superior a 50%; e designam-se por empresas nacionais (EN) aquelas empresas em que 100% do capital social é detido por investidores nacionais[5].

TABELA 2 – Evolução do peso das empresas estrangeiras e participadas em relação ao total do respectivo sector – 2000, 2003 e 2006

	2000		2003		2006	
Nº empresas (%)	**Total**	**SIC**	**Total**	**SIC**	**Total**	**SIC**
EE	0,8	1,1	0,9	1,3	1,0	1,4
EP	0,2	0,4	0,1	0,4	0,2	0,4
Emprego (%)	**Total**	**SIC**	**Total**	**SIC**	**Total**	**SIC**
EE	8,4	9,7	8,4	8,9	9,0	10,8
EP	2,3	3,5	2,2	4,6	2,2	4,4
Volume de vendas (%)	**Total**	**SIC**	**Total**	**SIC**	**Total**	**SIC**
EE	16,5	16,1	17,9	18,7	16,9	15,8
EP	6,2	9,7	6,7	13,6	7,6	17,2

Fonte: *Quadros de Pessoal* e cálculos dos autores.
EE: empresas estrangeiras (EE) são empresas em que mais de 50% do capital social é detido por investidores estrangeiros; EP: Empresas participadas são empresas em que a participação estrangeira no capital é positiva mas não superior a 50%.

Como se pode observar na Tabela 2, existe uma maior percentagem de EE e EP nos SIC do que na totalidade dos sectores, tendo-se verificado um ligeiro aumento do peso relativo das empresas de propriedade estrangeira na economia portuguesa no período de 2000 a 2006[6]. No que respeita ao emprego, também se verificou um aumento do peso do emprego criado pelas empresas de propriedade estrangeira, sobretudo nos SIC. Na verdade, a percentagem do emprego total criado pelas EE nos SIC aumentou de 9,7% em 2000 para 10,8% em 2006, e de 3,5% para 4,4% nas EP.

No que respeita ao peso do volume de vendas, os dados parecem evidenciar uma tendência de crescimento para as EP, quer nos SIC quer na totalidade dos sectores, e uma tendência de estabilização para as EE.

TABELA 3 – Evolução das vendas médias por trabalhador, SIC e total dos sectores 2000, 2003 e 2006

	2000		2003		2006	
Tipo de empresa	**Total**	**SIC**	**Total**	**SIC**	**Total**	**SIC**
EE	139,9	128,5	145,4	133,2	145,4	132,2
EP	129,0	134,1	138,3	133,3	127,8	105,3
EN	59,2	47,7	56,7	47,1	55,4	47,3

Fonte: *Quadros de Pessoal* e cálculos dos autores.
* Valores em milhares de euros, a preços constantes de 2000.

5 Não existe um consenso acerca do limite mínimo no capital social que o investidor estrangeiro tem que deter para que a empresa seja considerada estrangeira. Com efeito, a OCDE considera 10% como mínimo aceitável, mas outras definições incluem os 50% do capital social para que o investidor estrangeiro tenha um domínio efectivo na gestão da empresa.
6 Os valores referentes ao volume de negócios encontram-se deflacionados com base no IPC (ano base 2000). Apesar de ser questionável o uso do IPC para deflacionar o volume de negócios, consideramos ser aquele a melhor alternativa, dada a dificuldade em encontrar um outro índice para o sector dos serviços.

De acordo com os dados constantes na Tabela 3, verificamos também que as empresas estrangeiras são, em média, mais produtivas que as empresas nacionais quando se considera a produtividade medida pelo volume de vendas médio por trabalhador.

3.2. Modelo Econométrico

O modelo que se pretende estimar é um modelo em que a variável dependente, y, corresponde a uma proporção, nomeadamente à proporção de trabalhadores da empresa num determinado nível de habilitações/qualificações, como mais à frente iremos definir[7]. A variável dependente irá assumir valores compreendidos entre 0 e 1, isto é, $0 \leq y_i \leq 1$. Nestas circunstâncias, e como referem Papke e Wooldridge (1996), os modelos lineares não são os mais adequados pois padecem das mesmas desvantagens que o modelo linear de probabilidade no caso de variável dependente binária. Ou seja, não está assegurado que os valores estimados de y estejam compreendidos entre 0 e 1 e, por outro lado, não é razoável, assumir que os efeitos de uma dada alteração na variável explicativa x_j, sejam constantes no intervalo de valores admissíveis para o vector **x** das variáveis explicativas do modelo. Deste modo, os mesmos autores sugerem a utilização de um modelo *fractional logit* que ultrapassa as dificuldades referidas.

A forma funcional do modelo é a seguinte: $E(y/x_i) = G(\mathbf{x_i}\beta)$,

em que G(.) é a função distribuição logística e, portanto, $E(y/x_i) = \exp(\mathbf{x_i}\beta)/[1+\exp(\mathbf{x_i}\beta)]$. Para obter as estimativas dos coeficientes de regressão β, recorrer-se-á ao método da quasi-máxima verosimilhança.

Em particular, a especificação do modelo a estimar é a seguinte:

$$E(y_{it}/\mathbf{x}_{it}, \alpha_i) = G(\alpha_i + \beta_1 CSE1_{it} + \beta_2 CSE2_{it} + \beta_3 IDADE_{it} + \beta_4 LDIM_{it} + \beta_{5J}\sum_{J=1}^{6} REGJ_{it} + \beta_{6J}\sum_{J=1}^{48} CAEJ_{it} + \beta_{7T}\sum_{T=1}^{5} ANOT_t) \quad (1)$$

em que *i* representa a i-ésima empresa do sector de SIC, *t* o período de referencia e α_i um efeito fixo empresa específico. Na secção seguinte, procede-se à descrição de cada uma das variáveis incluídas em (1).

3.3. Variáveis

3.3.1. Capital humano

Por capital humano entende-se o conjunto de competências e conhecimentos que um ou mais trabalhadores detêm e que podem ser usados no processo produtivo. Normalmente estão relacionadas com o nível educacional formal ou com o trabalho e neste caso são desenvolvidas através de formação ou experiência. Neste artigo utilizamos cinco medidas para caracterizar a intensidade do capital humano das empresas e que correspondem às cinco definições da variável dependente. Assim, usou-se a percentagem de trabalhadores da empresa com pelo menos 12 anos de escolaridade (EDU) e a percentagem de licenciados (LIC) da empresa para medir as habilitações escolares. A percentagem de trabalhadores da empresa que pertencem aos quadros superiores (QS), a percentagem de profissionais altamente qualificados (PA) e a percentagem de engenheiros (ENG), foram as *proxies* utilizadas para medir as qualificações. Níveis mais elevados nestes rácios, significam níveis mais elevados de intensidade de capital humano e, logo, sinónimo de maiores competências profissionais e conhecimentos[8].

7 Habilitações e qualificações são conceitos que embora utilizados de forma quase indistinta na literatura são diferentes. As qualificações são competências específicas que são adquiridas essencialmente através do *learning by doing* ou do *on-the-job training*, enquanto as habilitações traduzem competências genéricas que se adquirem através da educação e da formação formal (Teixeira e Tavares-Lehmann, 2007).
8 Vários autores medem intensidade de capital humano pela percentagem de trabalhadores com determinado

Os dados reflectidos na Tabela 4 revelam que as empresas do sector dos SIC detêm uma maior percentagem de licenciados e de trabalhadores com pelo menos 12 anos de escolaridade, independentemente da propriedade do capital social. As empresas dos SIC possuem também uma maior percentagem de quadros superiores, de quadros médios e de profissionais altamente qualificados.

Em relação à influência da propriedade do capital, as empresas estrangeiras e com participação estrangeira apresentam uma maior percentagem de trabalhadores com elevada formação do que as empresas nacionais. As empresas estrangeiras possuem também uma maior percentagem de quadros superiores e médios, e de profissionais altamente qualificados. As diferenças são mais significativas quando se considera a totalidade dos sectores. Estes resultados, sem condicionantes, estão de acordo com a hipótese de que as empresas multinacionais empregam trabalhadores com maior nível de habilitações e qualificações (Almeida, 2004).

TABELA 4 – Habilitações escolares e qualificações dos trabalhadores (%), valores médios para 2000-2006 (excepto 2001)

	SIC			Todos os sectores		
	EE	EP	EN	EE	EP	EN
Percentagem de trabalhadores						
Com licenciatura	38,8	48,2	22,6	21,6	22,6	5,9
Com >=12 anos escolaridade	81,5	80,9	60,5	59,2	55,3	24,6
Percentagem de trabalhadores						
Quadros superiores e médios	31,9	37,4	29,1	18,9	23,1	22,1
Altamente qualificados	16,3	15,8	9,4	13,3	10,9	4,0
Engenheiros	6,0	6,8	2,1	4,5	5,0	0,8

Fonte: *Quadros de Pessoal* e cálculos dos autores.

3.3.2. Covariáveis: Propriedade estrangeira, idade, dimensão, localização geográfica e sector de actividade

A principal variável explicativa do nosso modelo é a propriedade do capital social. Tal como referido atrás, consideramos três categorias: a participação estrangeira no capital social é superior a 50% (CSE1), a participação estrangeira no capital social é positiva e não superior a 50% (CSE2), a participação estrangeira no capital social é nula (categoria omitida).

Foram utilizadas as seguintes variáveis de controlo: dimensão (logaritmo do número total de trabalhadores da empresa; LDIM) e idade (número de anos de actividade desde a data da constituição; IDADE) dado que estas podem afectar a política de recrutamento da empresa (Teixeira e Tavares-Lehmann, 2007). Também foram incluídas variáveis *dummy* para os vários sectores de actividade dos SIC[9] (CAE a 3 dígitos) e para a localização geográfica (ao nível das NUTSII), com o intuito de controlar para o facto da intensidade de capital humano poder estar associada com o sector de actividade dentro dos SIC ou com a localização geográfica da empresa.

No que respeita à dimensão da empresa, verifica-se que as empresas estrangeiras e com participação apresentam, em média, uma maior dimensão do que as empresas nacionais (ver Tabela 5). Estas últimas são, na sua grande maioria, empresas de menor dimensão, ou seja, 85% das empresas nacionais nos SIC têm menos de 10 trabalhadores. Igual percentagem se

nível de formação. Almeida (2004) e Teixeira e Tavares-Lehmann (2007) utilizam a percentagem de engenheiros e de trabalhadores com pelo menos 12 anos de escolaridade, enquanto Barbosa (2007) utiliza a percentagem de licenciados e de trabalhadores qualificados.
9 Para a totalidade dos sectores inclui as actividades económicas com CAE a 1 dígito.

observa quando se considera a totalidade dos sectores. Apenas 0,2% das empresas nacionais empregavam mais de 250 trabalhadores (0,5% para os SIC). Para as empresas estrangeiras e com participação estrangeira esta percentagem eleva-se, respectivamente, para 5,2% e 6,7% nos SIC e 6,7% nos dois casos para o total dos sectores.

No que respeita à idade não se verificam diferenças significativas entre as empresas estrangeiras e as nacionais (ver Tabela 6). Em ambos os casos verificamos que existe uma percentagem significativa de *Start-ups,* isto é, de empresas com menos de 10 anos de idade[10], mas que é mais elevada nos SIC do que na totalidade dos sectores. Estes resultados não estão de acordo com os obtidos por Teixeira e Tavares-Lehmann (2007), que encontraram uma percentagem muito menor, cerca de 13%, de *start-ups* para uma amostra de empresas de base tecnológica para o período de 2001-2003. Esta evidência, aliada ao facto de 68% das empresas consideradas na amostra utilizada por aquelas autoras empregarem entre 10 e 250 trabalhadores, parece sugerir que na lista de empresas da Markelink de 2004, que inclui todas as empresas localizadas em Portugal que declaram e publicitam actividades de I&D, há uma clara sub-representação das micro e pequenas empresas e de empresas recém-criadas.

TABELA 5 – Distribuição das empresas por escalões de dimensão (%), valores médios para 2000-2006 (excepto 2001)

	SIC			Todos os sectores		
	EE	EP	EN	EE	EP	EN
Micro empresas: 1-9	53,2	52,9	85,0	41,8	44,0	84,6
Pequenas: 10-49	27,8	24,4	12,2	32,3	30,0	13,4
Médias pequenas: 50-249	13,7	16,0	2,3	19,3	19,4	1,8
Médias grandes: 250-499	2,7	2,2	0,3	3,9	3,5	0,1
Grandes: >= 500	2,5	4,5	0,2	2,8	3,2	0,1

Fonte: *Quadros de Pessoal* e cálculos dos autores.

TABELA 6 – Distribuição das empresas por escalões de idade (%) e idade (nº de anos), valores médios para o período 2000-2006 (excepto 2001)

	SIC			Todos os sectores		
	EE	EP	EN	EE	EP	EN
Idade (n.º de anos)	10,80	10,97	11,11	13,60	13,80	11,73
Distribuição das empresas por idade (%):						
0-9 anos	60,9	54,0	58,6	50,6	48,9	52,2
10-19 anos	23,7	31,7	23,4	27,5	29,6	25,3
20-29 anos	4,8	5,9	7,1	7,2	8,0	9,2
>=30 anos	7,1	5,1	6,6	14,7	13,5	13,2
Não definido	3,5	3,3	4,3	0	0	0

Fonte: *Quadros de Pessoal* e cálculos dos autores.

Verificamos que a maioria das empresas estrangeiras e com participação estrangeira se situam na zona de Lisboa (NUTS II): 57,6 % e 50,6%, respectivamente, na totalidade dos sectores. Quando se considera os SIC, estes valores elevam-se para 73,8% e 69,8% (ver Tabela 7).

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TABELA 7 – Distribuição das empresas por região (NUTS II) (%), valores médios para 2000-2006 (excepto 2001)

	SIC			Todos os sectores		
	EE	EP	EN	EE	EP	EN
Norte	10,0	18,7	29,7	21,0	26,8	35,0
Centro	2,7	5,0	19,4	10,2	13,4	22,9
Lisboa	73,8	69,8	36,0	57,6	50,6	25,4
Alentejo	1,3	1,8	5,6	4,4	3,8	7,5
Algarve	6,0	2,0	5,7	4,3	2,9	5,5
Açores	0,2	0,0	1,6	0,2	0,5	1,8
Madeira	6,0	2,7	2,0	2,3	2,0	2,0

Fonte: *Quadros de Pessoal* e cálculos dos autores.

Finalmente, quanto à distribuição das empresas estrangeiras por sector de actividade económica, a actividade económica que apresenta uma maior percentagem de empresas estrangeiras e participadas é o «Comércio por grosso e a retalho» (CAE G), seguido pela «Actividade transformadora» (CAE D) e pelas «Actividades imobiliárias» (CAE K). Nos SIC, a maioria das EE e das EP estão no subsector 74 «Outras actividades de serviços prestados principalmente às empresas», e, dentro deste, no subsector 741 «Actividades Jurídicas, Contabilidade e auditoria …» e no subsector 748 «Outras actividades de serviços prestados principalmente às empresas».

3.4. Resultados empíricos

O modelo especificado em (1) foi estimado por recurso ao estimador *pooled fractional logit* ignorando, portanto, a estrutura em painel dos dados. Este estimador é consistente, se assumirmos que a componente não observada, α_i, não está correlacionada com as variáveis explicativas incluídas no modelo[11]. No intuito de termos em conta que os termos de perturbação do modelo podem exibir correlação temporal para cada empresa *i* e, para efeitos de comparação, usou-se ainda o estimador *fractional logit* com efeitos aleatórios. Este modelo assume que α_i segue uma distribuição normal de média nula e variância constante, ou seja, $\alpha_i \sim N(0, \sigma^2)$. Neste caso, no entanto, $Pr(y_{it} = 1 | x_{it}, \beta) \neq \Lambda(x_{it}\beta)$, pelo que os parâmetros do modelo não são directamente comparáveis com os do modelo *pooled fractional logit*. Na verdade, aquela probabilidade depende do parâmetro desconhecido, α_i, que o modelo não estima (Cameron and Trivedi, 2009).

Os resultados obtidos são apresentados na Tabela 8 para os SIC e total dos sectores. Os resultados obtidos pelo modelo *pooled fractional logit e* pelo modelo *fractional logit* com efeitos aleatórios não são, em geral, qualitativamente diferentes. Com excepção da variável dimensão, os efeitos estimados associados a cada uma das variáveis explicativas apresentam o mesmo sinal em qualquer dos modelos e são estatisticamente significativos. Em particular, verifica-se que, para todas as medidas utilizadas para a variável dependente, as empresas com participação estrangeira no capital social apresentam, tudo o resto constante, uma maior intensidade de capital humano (SIC e total dos sectores) do que as empresas nacionais.

11 Em alternativa, seria de todo o interesse abandonar este pressuposto, e usar o estimador de efeitos fixos que permitiria controlar para a heterogeneidade individual (permanente) não observada das empresas. No entanto, este método não permite identificar os efeitos das variáveis explicativas que são constantes ao longo do tempo. Como no nosso caso, as principais variáveis de interesse – CSE1 e CSE2 – são constantes no período considerado para a generalidade das empresas, não será possível identificar os seus efeitos se usarmos um modelo logit com efeitos fixos. De qualquer modo, as consequências resultantes de não se controlar para a heterogeneidade individual (permanente) não observada das empresas estão, de certo modo, minimizadas, devido à diversidade de informação utilizada para caracterizar as empresas.

TABELA 8 – Resultados da estimação para os SIC e todos os sectores, 2000-2006 (excepto 2001)

	pooled fractional logit					*fractional logit* com efeitos aleatórios				
	LIC	EDU	QS	PA	ENG	LIC	EDU	QS	PA	ENG
	SIC (N = 301823)					SIC (N = 301823)				
CSE1	0,7501*	0,8381*	0,1570*	0,3450*	0,6229*	0,3791*	0,4297*	0,1005**	0,2736*	0,4097*
	(0,0412)	(0,0482)	(0,0389)	(0,0456)	(0,0831)	(0,0344)	(0,0341)	(0,0652)	(0,0450)	(0,0893)
CSE2	0,9246*	0,8238*	0,4701*	0,2817*	0,7722*	0,4325*	0,3941*	0,2384*	0,1785**	0,4306**
	(0,0792)	(0,0895)	(0,072)	(0,0695)	(0,1394)	(0,0587)	(0,0514)	(0,0343)	(0,0708)	(0,1613)
IDADE	-0,0265*	-0,0187*	-0,0333*	0,0040*	-0,0236*	-0,0253*	-0,0178*	-0,0349*	0,0033*	-0,0259*
	(0,0008)	(0,0006)	(0,0008)	(0,0006)	(0,0024)	(0,0008)	(0,0005)	(0,0007)	(0,0006)	(0,0024)
LDIM	0,0526*	0,0297*	-0,2544*	0,1071*	0,0413*	0,0101***	-0,0276*	-0,3087*	0,1019*	-0,0136
	(0,0062)	(0,0053)	(0,0054)	(0,0067)	(0,0152)	(0,0060)	(0,0050)	(0,0055)	(0,0066)	(0,0156)
Constante	-2,6337	-0,6623	-0,2574	-3,2451	-5,6025	-2,2426	-0,4013	-0,1934	-3,1248	-5,0714
	(0,0892)	(0,0544)	(0,0528)	(0,0938)	(0,2975)	(0,0760)	(0,0435)	(0,0469)	(0,0873)	(0,2583)
Teste-Wald	14513,80	21365,79	16682,63	7925,46	7211,99	11045,71	18238,27	15859,70	6469,40	4916,05
p-value	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000
	Efeitos marginais					Efeitos marginais				
CSE1	0,1345*	0,1826*	0,0320*	0,0307*	0,0083*	0,0629*	0,1006*	0,0201*	0,0236*	0,0053*
CSE2	0,1735*	0,1795*	0,1017*	0,0245*	0,0112*	0,0730*	0,0923*	0,0490**	0,0150**	0,0057**
	Todos os sectores (N = 1836765)					Todos os sectores (N = 1836765)				
CSE1	1,1089*	1,2651*	0,0375***	0,8356*	1,1394*	0,5719*	0,5731*	0,0652*	0,5600*	0,7464*
	(0,0253)	(0,0211)	(0,0200)	(0,0264)	(0,0472)	(0,0486)	(0,0166)	(0,0183)	(0,0298)	(0,0611)
CSE2	1,0938*	1,0804*	0,2968*	0,5715*	1,1047*	0,4781*	0,4123*	0,1439*	0,3677*	0,6290*
	(0,0505)	(0,0419)	(0,0398)	(0,0497)	(0,0878)	(0,0270)	(0,0284)	(0,0369)	(0,0541)	(0,1327)
IDADE	-0,0135*	-0,0140*	-0,0190*	0,0059*	-0,0132*	-0,0143*	-0,0134*	-0,0191*	0,0050*	-0,0139*
	(0,0004)	(0,0003)	(0,0003)	(0,0004)	(0,0009)	(0,0006)	(0,0003)	(0,0003)	(0,0004)	(0,0009)
LDIM	0,1041*	0,0688*	-0,3035*	0,1538*	0,1465*	0,0198*	-0,0177*	-0,3566*	0,1399*	0,0572*
	(0,0038)	(0,0025)	(0,0022)	(0,0037)	(0,0079)	(0,0040)	(0,0024)	(0,0024)	(0,0039)	0,0092)
Constante	-3,1523	-1,4544	-0,5252	-3,6280	-5,2690	-2,7723	-1,0965	-0,4137	-3,4480	-5,0622
	(0,0117)	(0,0007)	(0,0067)	(0,0128)	(0,0300)	(0,0117)	(0,0007)	(0,0067)	(0,0128)	(0,0300)
Teste-Wald	71352,71	112855,97	69313,62	29783,50	15770,72	43833,25	72822,62	73029,29	16920,79	8689,74
p-value	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000
	Efeitos marginais					Efeitos marginais				
CSE1	0,0804*	0,2827*	0,0062***	0,0415*	0,0128*	0,0344*	0,1166*	0,0106*	0,0247*	0,0070*
CSE2	0,0793*	0,2373*	0,0530*	0,0251*	0,0123*	0,0276*	0,0812*	0,0240*	0,0148*	0,0055*

Fonte: A especificação inclui ainda *dummies* temporais, sectoriais e regionais (NUTS II). Os valores que aparecem na primeira linha são as estimativas dos coeficientes e os que aparecem entre parêntesis são os desvios padrões robustos à presença de correlação temporal nos erros aleatórios para cada empresa i. Os símbolos *, ** e *** significam que as variáveis são estatisticamente significativas a 1%, 5% e 10%, respectivamente.

Considerando o modelo *pooled fractional logit*, e de acordo com as estimativas obtidas para os efeitos marginais estima-se que, em média, as empresas com mais de 50% de capital estrangeiro apresentem uma percentagem de licenciados (LIC) superior a uma empresa nacional em 13,45 pontos percentuais (p. p.), mantendo-se tudo o resto constante[12]. Quando a variável dependente é medida pela percentagem de trabalhadores com pelo menos 12 anos de escolaridade (EDU) este acréscimo é de 18,26 p. p., mantendo-se tudo o resto constante. Para as qualificações este acréscimo é menor: 3,20 p. p. para a percentagem de quadros superiores (QS), 3,07 p. p. para os profissionais altamente qualificados (PA) e apenas 0,83 p. p. para a percentagem de engenheiros (ENG). Estes resultados são consistentes com os obtidos por Teixeira e Tavares-Lehmann (2007), que evidenciaram que o impacto da propriedade estrangeira sobre a intensidade de capital humano é maior quando se considera uma medida do capital humano geral como a escolaridade do que quando se utiliza uma medida do capital humano específico como as qualificações[13].

Para as empresas cuja participação estrangeira não excede os 50% do capital social estima-se que, em média, apresentem um acréscimo de 17,35 p. p. na percentagem de licenciados face às empresas nacionais, mantendo-se tudo o resto constante. Quando a variável dependente é EDU este acréscimo é de 17,95 p. p., para os QS é de 10,17 p. p., 2,45 p. p. para a percentagem de PA e apenas 1,12 p. p. para a percentagem de ENG, mantendo-se tudo o resto constante. Estes resultados parecem sugerir que o impacto de ter propriedade estrangeira sobre a intensidade do capital humano é relativamente independente do montante da participação estrangeira no capital social da empresa.

A idade tem um efeito negativo na intensidade do capital humano (à excepção dos PA), isto é, as empresas mais novas apresentam uma maior intensidade de capital humano. Este resultado não é inesperado, visto que, em geral, as empresas mais velhas possuem uma força de trabalho com mais antiguidade ou idade e, portanto, com menos habilitações escolares. Até que possa ocorrer uma substituição da força de trabalho actual por outra mais qualificada vai demorar algumas gerações.

A dimensão tem um efeito positivo (à excepção dos QS), isto é, as empresas de maior dimensão tenderão a contratar uma força de trabalho mais qualificada e escolarizada[14]. Estes resultados contradizem os obtidos por Teixeira e Tavares-Lehmann (2007) que obtiveram um efeito negativo e estatisticamente significativo para a variável dimensão. Este impacto positivo da dimensão poderá ser explicado por vários motivos, nomeadamente, a existência de mercados de trabalho internos que tornam estas empresas mais atractivas sob o ponto de vista dos trabalhadores mais qualificados ou escolarizados e que têm maiores possibilidades de progressão na carreira.

Por último, vale a pena referir que as empresas com sede na região de Lisboa tendem a ter uma maior intensidade de capital humano. Uma possível explicação poderá ter a ver com as diferentes restrições em termos de oferta de trabalho que as várias regiões enfrentam.

Em síntese, verifica-se que, para todas as medidas utilizadas para a variável dependente, as empresas com participação estrangeira no capital social apresentam, tudo o resto constante, uma maior intensidade de capital humano (SIC e total dos sectores) do que as empresas nacionais. Também se constata que o efeito de ter propriedade estrangeira é superior quando o capital humano é medido pelas habilitações escolares do que quando é medido pelas qualificações.

12 Os efeitos marginais para o modelo *logit* com efeitos aleatórios são calculados assumindo $\alpha_i = 0$, o que pode não corresponder a um elemento representativo da população em estudo.
13 Refira-se ainda que as autoras obtiveram uma estimativa do efeito marginal para a variável EDU de 8,1 p. p. usando o método dos mínimos quadrados ordinários. Para a variável ENG essa estimativa é de 3,6 p. p..
14 No modelo de efeitos aleatórios o efeito da dimensão sobre a variável dependente EDU também é negativo e estatisticamente significativo.

Por outro lado, os resultados também parecem sugerir que a maior intensidade de capital humano é independente da percentagem que os investidores estrangeiros possuem no capital social da empresa.

4. Conclusão

A análise incide sobre a economia portuguesa, país que tem implementado uma política activa de desenvolvimento dos SIC e simultaneamente de atracção de IDE, apresentando no entanto elevados défices de qualificações (Bernardino *et al.*, 2010; Teixeira e Tavares-Lehmann, 2007). O estudo apoia-se na base de dados dos *Quadros de Pessoal*, extremamente representativa do sector privado da economia portuguesa. O trabalho analisa o sector dos serviços dada a sua importância em termos de output, emprego e investimento estrangeiro. De acordo com o que julgamos saber, é o primeiro estudo nesta temática que analisa, em termos absolutos e comparativos face aos restantes sectores, os serviços intensivos em conhecimento, recorrendo a uma base de dados representativa das empresas portuguesas no sector privado da economia adoptando uma metodologia econométrica adequada.

Os resultados empíricos confirmam que as empresas multinacionais apresentam uma maior intensidade de capital humano, embora não exista evidência de uma grande heterogeneidade associada ao grau de participação estrangeira no capital social. Estes resultados são válidos para o sub–sector dos serviços intensivos em conhecimento, bem como para a totalidade dos sectores.

Neste sentido, Portugal deve seguir uma política de atracção de IDE intensivo em conhecimento e ao mesmo tempo uma política de recursos humanos atenta ao tipo de competências que é necessário desenvolver. Um stock de capital humano leva anos a construir (Teixeira e Tavares-Lehmann, 2007) pelo que se torna fundamental uma política de educação e formação profissional que não dependa do ciclo político. É necessário que a sociedade globalmente tenha consciência da importância do capital humano como elemento gerador de riqueza a longo prazo.

Como sugestão de pesquisa futura, seria interessante analisar se as empresas multinacionais têm também um comportamento diferenciador em matéria de formação profissional. Qual a natureza das competências transmitidas pelo IDE e, de que forma, as instituições de formação (escolas de negócios, por exemplo) poderão interagir mais com as empresas estrangeiras (e nacionais) e complementar o *learning-by-doing* (Blomström e Kokko, 2003).

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Mind the Gap: Education Inequality at the Regional Level in Portugal, 1986-2005*

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resumo

Portugal é um dos países mais desiguais em termos de rendimento entre os países desenvolvidos. De 1980 a 2005, a desigualdade de rendimento manteve valores elevados, resultado sobretudo do aumento da desigualdade dos rendimentos do trabalho. Dada a estreita ligação entre educação e rendimentos do trabalho, é fundamental analisar a distribuição de educação. O objectivo principal deste trabalho é avaliar empiricamente a desigualdade de educação em Portugal a um nível regional entre 1986 e 2005. Os resultados apontam para um aumento do nível médio de educação da força de trabalho em simultâneo com uma diminuição da desigualdade de educação, ao nível nacional. Contudo, várias regiões, as inicialmente mais pobres em educação, apresentam um aumento da desigualdade. Comprovamos também empiricamente a existência de uma curva de Kuznets de educação.

résumé / abstract

Portugal figure parmi les pays développés comme un des pays des plus inégaux en termes de revenu. Durant 1980-2005, l'inégalité du revenu maintient des valeurs élevées alimentée surtout pas une croissance de l'inégalité des gains. Du fait de l'existence d'une relation étroite entre l'éducation et les gains, l'étude de la distribution de l'éducation est importante. D'abord nous mesurons l'inégalité de l'éducation au niveau régional, au Portugal, entre 1986 et 2005. Nos résultats confirment une augmentation du niveau moyen de l'éducation de la force de travail accompagnée par une diminution de l'inégalité pour l'ensemble du pays. Nonobstant, certaines régions exhibent une augmentation de l'inégalité. Finalement, nous obtenons des résultats empiriques qui supportent l'hypothèse de la courbe de Kuznets pour l'éducation.

Portugal stands as one of the most unequal countries in terms of income among the developed countries. Over the period 1980-2005, income inequality kept high, fostered mainly by a monotonic increase in earnings inequality. Given the close link between education and earnings, it is of major importance to study the distribution of education. This paper examines the distribution of education at the regional level in Portugal between 1986 and 2005. Our results indicate that education inequality decreased for the whole country as the average education level of the workforce rose, over the sample years. This finding does not apply at the regional level however, with several districts initially poor in terms of education exhibiting an increase in education inequality. The evidence also supports the existence of a Kuznets curve of education: as the average level of education rises, education inequality first increases, and, after reaching a peak at 5.13 years of schooling, starts declining.

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1. Introdução

Income inequality has been a permanent theme on economic research, whereas human capital inequality is a very recent topic of study. The importance of human capital and its distribution only emerged after the surge of endogenous growth theories during the 1980s. One can ask about the relevance of this topic *per se* for Economics, which then leads to the question, *Is inequality really a bad thing*? According to some theories, inequality can be detrimental to economic growth and reduce individual welfare. For countries such as Portugal, that presents persistently high income inequality levels, the study of inequality is thus of great importance.

The stock of human capital is a fundamental determinant of a country's growth performance as we are rapidly moving towards a knowledge-based economy. Endogenous growth theories brought to the front line the importance of this production factor not only as a major inductor of innovation but also as an essential tool for absorption and adaptation to new knowledge and technologies. Furthermore, at the individual level, the stock of human capital is a major determinant of individual employability and earnings. In turn, from an intergenerational perspective, the educational level of the parents decisively influences the educational level achieved by their offspring. The level and the distribution of human capital are thus important determinants of the growth performance and the level of social cohesion of a country and should be the focus of research.

The intergenerational transmission of inequality is a matter of much concern, since it lowers the equality of opportunity among the young and produces economic inefficiencies given the waste of skills from children with a low family background. The vicious cycle of inequality is a complex network of mechanisms. First, given the liquidity constraints, income inequality leads to human capital inequality. In other words, poor households will lack the financial resources to invest in their children's education. Additionally, parents' educational level strongly determines the educational attainment of children, which means that human capital inequality will tend to persist over generations. These mechanisms act therefore as intergenerational mechanisms of inequality reproduction. At the same time, there will be an intra-generational effect, since the distribution of human capital will determine the contemporaneous distribution of income, via wages and individual employability. And if inequality prevents poorer individuals and their children from investing in human capital, then inequality is detrimental to growth.

The main goal of our paper is to gauge education inequality at the regional level. Our analysis covers the eighteen Portuguese *distritos* and two insular regions, from 1986 to 2005. We also investigate if the evolution of education inequality at regional level fits the hypothesis of a Kuznets curve of education.

In the next section we provide a brief overview of the theoretical and empirical studies that focus on the interactions between inequality and economic growth. We also review the empirical studies that have explored the hypothesis of a Kuznets curve of education and summarize the evolution of income and earnings inequality in Portugal over the sample period. In section 3, we develop a pioneering analysis of education inequality in Portugal at the regional level. Section 4 concludes.

2. Literature review

a. Inequality and economic growth

No definite sign can *a priori* be anticipated for the relationship between inequality and economic growth, given the numerous links between the two variables. The main channels through which inequality impacts economic growth can be nevertheless summarized into four groups: (i) borrowing constraints and the investment in physical and human capital; (ii) fiscal policy; (iii) socio-political instability and macroeconomic volatility; and (iv) saving rates behaviour (Perotti, 1996; Aghion *et al.*, 1999; Barro, 2000).

The first channel considers that in the presence of credit constraints the access to certain investment opportunities (physical and human capital) will depend on the initial individual distribution of income and wealth and, as a result, a reduction in inequality would lead to an increase in investment and growth (see e.g. Galor & Zeira, 1993; Perotti, 1996). However, if setup costs of physical investments are sizeable with respect to the median income, a reduction in inequality will be detrimental. It is, however, expected that this channel will produce larger effects in developing countries, where credit constraints are more pervasive (Barro, 2000).

According to the second channel, the level of taxation in the economy is determined by the median voter, i.e. the agent with the median level of income. In more unequal economies, where the median voter is thus relatively poor, this agent will require deeper redistributive policies through voting (the political mechanism). Hence, given that these expenditures are in part financed by distortionary taxes, the more unequal a society is, the larger the distortionary effect over the economy, resulting in less investment and growth (Bertola, 1993; Alesina and Rodrik, 1994; Persson and Tabellini, 1994; Aghion *et al.*, 1999).

Additionally, unequal societies tend to be more unstable, with frequent riots and other antisocial behaviours, which waste resources and time, leading to lower productivity and growth (see e.g. Alesina and Perotti, 1996; Perotti, 1996). There is also empirical support for claiming that higher inequality is linked to greater macroeconomic volatility, mainly resulting from socio-political instability (Aghion *et al.*, 1999) and higher sensitivity to adverse shocks. This third transmission mechanism is known as the socio-political instability channel.

The fourth channel predicts a positive impact of inequality on growth, as higher inequality implies higher savings rates and, consequently, higher investment and growth. This channel is based on the idea that the savings rate is a positive function of the level of income, which is the same as saying that rich people exhibit a higher savings rate (Barro, 2000).

Although the majority of the channels of influence described above point to a negative relationship between inequality and growth, especially for poor countries, given their higher socio-political instability, macroeconomic volatility, and larger credit constrains, empirical studies have provided mixed results. For instance, Perotti (1996) arrived at a negative relationship between inequality and growth, while Barro (2000) found a positive link between inequality and growth for rich countries although for the joint sample of rich and poor countries the sign was never statistically significant. But this conflicting evidence seems to result more from differences in methods than anything else, namely from: (i) different econometric specifications; (ii) the choice of income to assess inequality instead of wealth, the variable used in theoretical models; and (iii) different inequality measures [1].

b. The Kuznets Curve of education

The Kuznets curve (Kuznets, 1955) establishes an inverted-U relationship between economic development and inequality by relating output per capita to a measure of income inequality[2]. Given the close link between the level of human capital/education and the level of income, some researchers tried to find a similar relationship between the level of human capital/education and inequality in its distribution[3].

1 Dominics, Groot and Florax (2006) apply meta-analysis to 22 empirical studies on inequality and growth and find evidence that the variation in the inequality coefficient estimates are systematically associated with differences in estimation methods, sample coverage and data quality.
2 The transition from an agricultural-rural economy, exhibiting low inequality, to an industrial-urban economy is considered to be responsible for the initial increase in inequality. The massive industrialization and the equalization of returns across sectors will eventually lead to a decrease in inequality.
3 In this paper inequality is computed relative to the distribution of years of formal education of workers, similar to what is done in Birdsall and Londoño (1997) and Castelló and Doménech (2002), that build inequality measures based on data on average years of schooling from Barro (1993; 1996; 2001) and Nehru, Swanson and Dubey (1995).

Initial studies by Ram (1990) and Londoño (1990) were favourable to the idea of a Kuznets curve of education. Ram (1990), using cross-section data for 94 countries, obtained an inverted-U relationship between average years of schooling and the standard deviation of education, reaching a peak at 6.8 years of schooling. Londoño (1990) applying a similar methodology found the same inverted-U shaped curve. More recently, De Gregorio and Lee (2002), using panel data covering an interesting number of countries over a period of three decades (1960-1990), also found a Kuznets curve of education, using the standard deviation of years of schooling, again an absolute measure of inequality.

More recent studies (Thomas, Wang and Fan, 2001; Checchi, 2001; Castelló and Doménech, 2002; Lim and Tang (2008)) argue that the Kuznets curve of education is a direct consequence of using absolute measures of inequality, such as the standard deviation. Using relative measures of inequality, such as the Gini coefficient, leads to a negative relationship between education inequality and average years of schooling instead, which is a consequence of the asymptotical behaviour of the two types of measures (see Thomas, Wang and Fan, 2001). Some studies have nevertheless been able to find an inverted-U relationship between average years of schooling and the education Gini. Lin (2007), in an intra-country study for Taiwan between 1976 and 2003, found indeed support in favour of the hypothesis of a Kuznets curve of education, using the Gini index.

Another recent related debate concerns the specification of human capital to use when the objective is to measure inequality in its distribution and analyse the respective relationship with the average level. For instance, Lim and Tang (2008) consider that conclusions based on education/years of schooling inequality might be misleading and adopt a Mincerian specification of human capital as the conceptually most appropriate. They argue that the Kuznets curve of (Mincerian) human capital, instead of the Kuznets curve of education, is the 'natural explanation' for the Kuznets curve of income. Using the Mincerian specification for human capital (instead of years of schooling) and the corresponding inequality measure, the authors confirm the hypothesis of a Kuznets curve of human capital using the Gini index, i.e. a relative measure of inequality, for a sample of 99 countries over the period 1960-2000.

c. The evolution of income and earnings inequality in Portugal since the 1980s

The distribution of education is an important explanatory factor of the distribution of income or earnings as pointed out by several studies.

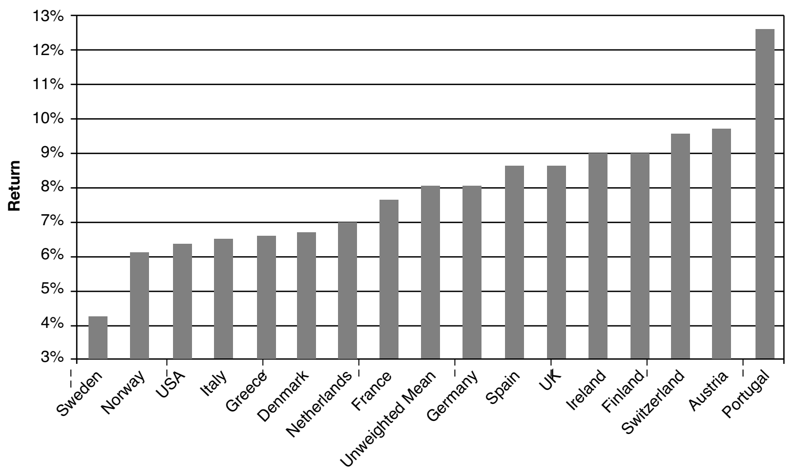
Gouveia and Tavares (1995) found a decrease in income inequality in Portugal during the 1980s, based on estimations from the Household Budget Survey (IOF). The authors suggested several reasons for this behaviour: the reduction in inequality of the distribution of years of schooling; the Portuguese comparative advantage in labour-intensive industries, with trade liberalization during this period resulting in higher demand for low-skilled workers; and the increasing equalising effect of redistributive policies. In contrast, Cardoso (1998), investigating the evolution of earnings inequality between 1980 and 1992 found an increase in earnings inequality. According to this author, the Portuguese earnings distribution has a compressed bottom and a stretched top, meaning that the problem of earnings inequality was that the upper wages were very high given the overall distribution. These, apparently, contradictory findings can perhaps be reconciled if one takes into account that during this period there was an increase in earnings inequality (and capital income), but that this evolution was more than offset by the equalising effect of direct taxes (Rodrigues, 1994).

The 1990s show a more mixed picture. In the first half of the 1990s, in particular, there was an inversion in the downward trend observed in the 1980s, with the high-income households benefitting from the highest income growth rates (Rodrigues, 2007). In the second half, in turn, there seems to be no clear trend. Thus, while Sologon and O'Donoghue (2009) report an unambiguous increase in earnings inequality based on earnings variance estimation, Budria (2007), using data from the European Community Household Panel, showed a decrease in earnings inequality between 1994 and 2001, with a statistically significant decrease in the Gini coefficient for earnings.

For the 2000-2005 period, the most recent period for which income inequality studies are available, Alves (2009), drawing from the 2005/06 Household Expenditure Survey (IDEF)[4], identifies a slight increase in inequality for monetary and total income.

Returns to education seem to have played a major role in the increase of earnings inequality since the 1980s. Firstly, the high returns to education in Portugal (see Figure 1) and its increase in recent years have fostered between-group earnings inequality, since the gap between skilled and unskilled workers has increased. Secondly, the increase in within-group inequality can also be attributed to returns to education, given that these returns increase along the conditional distribution, i.e. the distribution controlling for observable characteristics (Martins and Pereira, 2004) with the most skilled workers experiencing the highest earnings increase. As an illustration, Carneiro (2008) found that education explains 40 to 50% of wages inequality in Portugal in 2004[5].

Figure 1 – Returns to schooling in selected developed countries



Source: Martins and Pereira (2004). Based on OLS estimations.

TABLE 1 – Evolution of inequality for total income and monetary income, 1980-2005

	Total Income			Monetary Income		
	Gini Index	Atkinson (ε=0.5)	Atkinson (ε=2)	Gini Index	Atkinson (ε=0.5)	Atkinson (ε=2)
1980	0.3193	0.0830	0.2934	-	-	-
1989	0.3169	0.0818	0.2886	0.3285	0.0880	0.3393
1995	0.3473	0.0979	0.3205	0.3576	0.1048	0.3520
2000	0.3481	0.0985	0.3140	0.3658	0.1088	0.3490
2005	0.3437	0.0976	0.3099	0.3729	0.1153	0.3617

Source: Rodrigues (1996), for 1980, and Rodrigues (2007), for 1989, 1995 and 2000. The values for 2005 were directly provided by Nuno Alves to whom we are very grateful. All the estimations were drawn from the Household Budget Survey.

4 This survey, also carried out by Statistics of Portugal (INE), was the successor of the IOF.
5 Martins and Pereira (2004) argue that the factors that explain the different returns to schooling within the same educational group (such as over-education, natural ability, school quality or the field of study) produce larger effects on the group of highly-qualified workers, and therefore we should expect greater earnings dispersion within this group than within other educational groups. These authors try to overcome the widespread idea that wage inequality would be minimized solely by promoting higher schooling levels.

In Table 1 we present some key inequality measures for the distributions of total and monetary income taken from selected studies (Rodrigues (1996, 2007)). As it can be seen, all measures show a downward trend over the 1980s, followed by an increase during the 1990s. In the early 2000s, the figures for the distribution of total income show a very slight decrease, while the indexes for the distribution of monetary income show a clear increase.

3. Education inequality at the regional level in Portugal

3.1. The data

Our dataset is drawn from *Quadros de Pessoal* (QP), an annual census survey conducted by the Portuguese Ministry of Labour that covers all firms with wage earners[6]. The dataset collects information on the characteristics of workers (e.g. age, gender and the highest completed level of education) and firms (e.g. sales, number of employees, industry and region). QP also records information on workers' monthly earnings, which include basic earnings, regular subsidies, irregular subsidies and overtime pay, and on hours of work. All the information refers to October of each year. Public administration workers and those serving in the armed forces are absent from QP. For this study, we selected three data points, 1986, 1996, and 2005, with 1,722,455, 1,955,792, and 2,656,124 workers, respectively.

3.2. Methodology and concepts

Due to data limitations, the majority of empirical studies on the relationship between inequality and growth use inequality measures for the income distribution, although the theoretical literature focus on the link between the distribution of wealth and growth. Since human capital (or schooling) as been shown to be an even more important determinant of the distribution of wealth, the measures analysed should focus on human capital or education inequality rather than on income inequality.

Our paper focus is therefore on education inequality. The variable that will be used to measure the level of education of the labour force is years of schooling of workers. The geographical focus is the eighteen Portuguese *Distritos*, plus Madeira and Açores. *Distritos* are a territorial and administrative division of the Portuguese mainland.

All inequality measures mirror different subjective views about the distribution under analysis (Fields, 2001). However, and despite important differences across the different measures, the following four properties are, in general, required: (i) anonymity, which assumes that two distributions are equally unequal if one is obtained from a permutation of the other; (ii) income homogeneity, which implies that inequality is independent from the scale in which income is measured; (iii) population homogeneity, meaning that if a distribution is a replication of another, then they are equally unequal; (iv) the Pigou-Dalton transfer principle, which imposes that the result of an income transfer from a relatively rich person to a relatively poor one (without changing their position in the distribution and the mean of the distribution) is a reduction in inequality.

We select the following measures of inequality: the Gini index (G), the Atkinson index (A) and the Theil's first measure (T). These inequality indices can be extrapolated in order to analyse education inequality simply by substituting years of schooling for income in the definitions of the selected indices. (The corresponding definitions are given in Appendix A.)

Each measure reacts differently to changes in the shape of the distribution: the Gini index is sensitive to changes in the middle of the distribution[7]; Theil's first measure reacts mainly to

6 *Quadros de Pessoal* database is provided by Gabinete de Estratégia e Planeamento, Ministério do Trabalho e da Solidariedade Social (GEP – MTSS).
7 In the case of education inequality, the Gini index also becomes very sensitive to the share of population uneducated (with zero years of schooling). In the presence of uneducated individuals, the Lorenz curve becomes truncated along the horizontal axis which influences a great deal the value of the education Gini (see

changes at the bottom end of the distribution; and, the sensitivity of the Atkinson index to different parts of the distribution depends on the parameter that reflects inequality aversion, ε[8].

A common way to obtain a visual picture of inequality is to plot the Lorenz curve. In our study, this curve depicts the cumulative percentage of education acquired by each cumulative percentage of population (from the lowest to the highest in terms of years of schooling). The closer the Lorenz curve is to the 45 degree line (the perfectly equal distribution line), the more equal is the distribution under consideration. A subsequent concept is Lorenz-dominance, which allows one to say that if a Lorenz curve, say for distribution X, lies for some point above and never below another Lorenz Curve, associated to a distribution Y, then X Lorenz-dominates Y (or $L_X>L_Y$). The final result is that X is more equal than Y, according to the Lorenz criterion. Given Lorenz-dominance, an ordinal ranking can be obtained from a broad set of inequality measures, so that $L_X>L_Y \Rightarrow I(X)>I(Y)$, where I(.) is some measure of inequality. Examples of these measures are the Gini index, the Theil indices, the Atkinson index and the coefficient of variation. Another group of measures, said to be weakly Lorenz-consistent, verify the condition $L_X>L_Y \Rightarrow I(X)\geq I(Y)$. The various quantile ratios are a case in point of the latter group of measures. The two other possible situations are: (i) Lorenz curves coincidence, meaning that both distributions are equally unequal; and (ii) Lorenz curves crossing, which allows no comparison based on the Lorenz criterion (Fields, 2001). Both inequality measures, strongly and weakly Lorenz-consistent, satisfy $L_X>L_Y \Rightarrow I(X)=I(Y)$. Our empirical analysis uses the statistical software R and Lorenz dominance analysis (and the corresponding inequality measures referred above)[9].

3.2. Education inequality

In our analysis, educational attainment is given by the number of years of schooling corresponding to the highest completed level of education of workers from QP. (See Appendix B for definition and methodology.) The distribution of education and the corresponding inequality indices for 1986, 1996 and 2005 are presented in Tables 2-5. First we look at each cross-section separately and then overtime. In each case, we first analyse the chosen summary measure of education for the entire Portuguese economy and by region, and then present the inequality indices. Finally, we test the hypothesis of a Kuznets curve of education.

(i) The 1986 cross-section

According to Table 2, in 1986, average schooling in the Portuguese workforce was equal to 5.46 years[10], ranging from 4.68 years in Braga to 6.37 years in Lisboa. Inter-regional dispersion is small, since the coefficient of variation for average years of schooling is only 4.2%. If one includes the region of Lisboa, the coefficient of variation increases to 7.3%, which means that dispersion remains small anyway.

Table 3 shows the estimated Gini coefficient. For the entire country, the coefficient is equal to 0.2844. The inter-regional dispersion is now larger at 10.9%, with Braga having the least unequal index (at 0.2129) and Portalegre the most unequal (at 0.3141). Considering the other inequality indices, in Table 4 and in Figure 2, the ranking of the regions according to the different measures does change. Nonetheless, Braga is the least unequal region irrespective of the selected index, which means that Braga Lorenz-dominates all the other regions.

e.g. Morrisson and Murtin (2007)). Our study is not influenced by this problem since we assume that the lowest level of education corresponds to one year of schooling, a common assumption when measuring human capital (also known as nonzero specification).

8 We consider ε equal to 0.5 in order to make the Atkinson index more sensitive to changes in the top end of the distribution as lower values of ε put greater weight in the highest incomes.

9 The software R is available from http://www.r-project.org/.

10 Despite some methodological differences, our values for average years of schooling are very close to those reported by Teixeira (2005).

TABLE 2 – Average years of schooling

Position	1986		1996		2005		Growth rate 1986-2005
	Portugal	**5.46**	**Portugal**	**6.587**	**Portugal**	**7.805**	**42.9%**
	Littoral	5.526	Littoral	6.655	Littoral	7.887	42.7%
	Interior	4.86	Interior	6.07	Interior	7.308	50.4%
1	Lisboa	6.373	Lisboa	7.602	Lisboa	8.706	36.6%
2	Setúbal	5.327	Setúbal	6.892	Setúbal	8.126	52.5%
3	*Açores*	5.325	Faro	6.665	Faro	7.877	49.0%
4	Faro	5.287	Coimbra	6.436	Coimbra	7.708	45.9%
5	Coimbra	5.284	*Madeira*	6.423	Santarém	7.58	54.0%
6	Porto	5.224	Bragança	6.412	Viana do Castelo	7.58	50.8%
7	Bragança	5.118	Porto	6.302	*Madeira*	7.567	49.9%
8	Leiria	5.059	Santarém	6.294	Leiria	7.555	49.3%
9	*Madeira*	5.049	*Açores*	6.248	Porto	7.541	44.4%
10	Viana do Castelo	5.026	Leiria	6.224	Bragança	7.523	47.0%
11	Aveiro	4.96	Viana do Castelo	6.206	Évora	7.388	56.6%
12	Viseu	4.943	Vila Real	6.196	Vila Real	7.349	49.3%
13	Vila Real	4.923	Viseu	6.128	Castelo Branco	7.33	50.6%
14	Santarém	4.921	Beja	6.073	Aveiro	7.329	47.8%
15	Castelo Branco	4.868	Guarda	6.016	Viseu	7.269	47.1%
16	Guarda	4.839	Castelo Branco	6.006	Portalegre	7.246	52.2%
17	Beja	4.792	Évora	5.975	Beja	7.235	51.0%
18	Portalegre	4.761	Aveiro	5.94	Guarda	7.219	49.2%
19	Évora	4.718	Portalegre	5.926	*Açores*	7.188	35.0%
20	Braga	4.677	Braga	5.738	Braga	7.037	50.5%
	Coefficient of variation	*7.25%*		*6.52%*		*5.03%*	
	Unweighted mean	*5.0737*		*6.2851*		*7.51765*	

Notes: Hereafter, Litoral regions are in light-grey and the Interior ones are in dark-grey. The insular regions are in italics.

One interesting feature is that Braga is the least unequal region, whereas the region with the highest educational attainment, Lisboa, is the most unequal, except for the three districts, Portalegre, Beja and Évora, that altogether form one macro-region called *Alentejo*, one of seven NUTS2 regions[11]. A look at the shape of both distributions, in Table 5, allows to derive some important conclusions: (i) Braga and Lisboa display a very similar bottom, with the first decile, the first quartile and the median presenting the same value (4 schooling years); (ii) Braga exhibits a very compressed top, the third quartile and the ninth decile present the same value (6 years of schooling), while Lisboa depicts a stretched and unequal top, corresponding to 9 years in the

11 Alentejo is one of the seven Portuguese NUTS2 regions; the others are North, Centre, Lisboa, Algarve, Madeira and Açores. As far as inequality is concerned, Alentejo displays a very particular behaviour compared to all the other regions. It started with one of the lowest education levels and the highest inequality value (very stretched top and bottom), instead of a compressed distribution around low values of years of schooling similar to the other education-poor districts. Furthermore, it exhibited a downward trend in inequality while increasing its education level (as the bottom became more compressed around medium schooling levels).

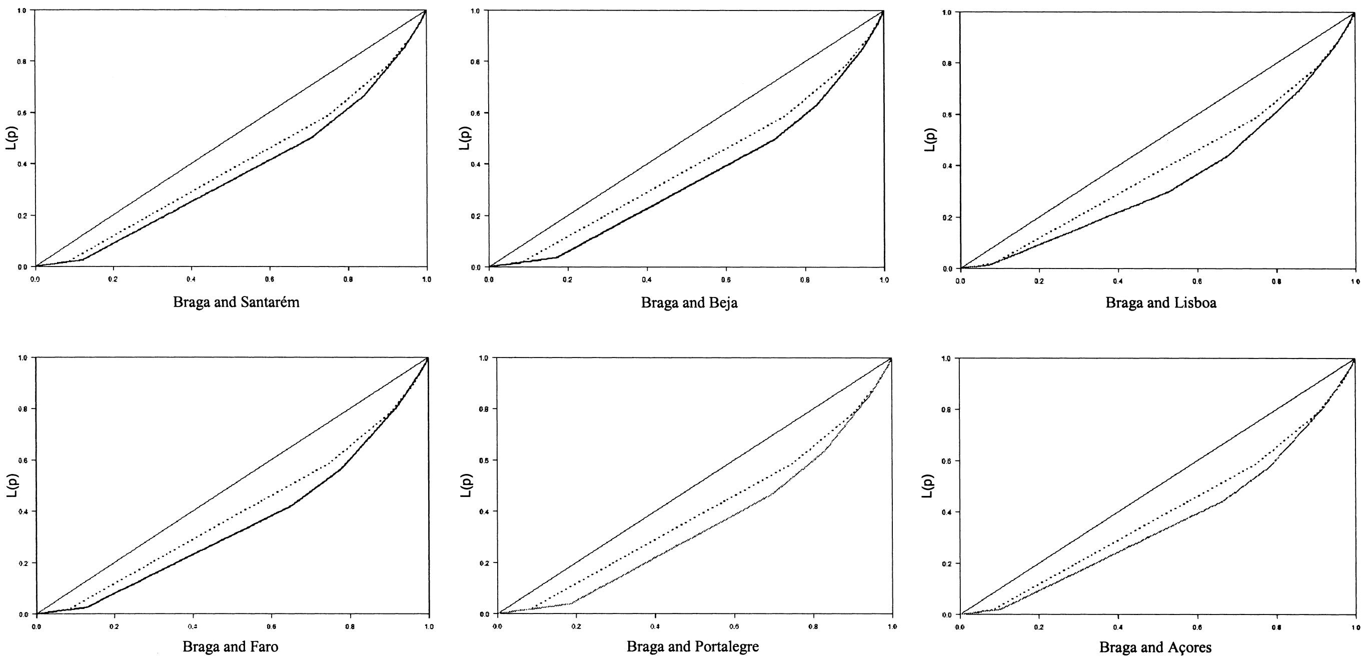
TABLE 3 – Gini coefficients

Position	1986		1996		2005		Growth rates 1986-2005	1986-1996	1996-2005
	Portugal	**0.2844**	**Portugal**	**0.2674**	**Portugal**	**0.255**	**-10.3%**	**-6.0%**	**-4.6%**
	Littoral	0.285	Littoral	0.2678	Littoral	0.2534	-11.1%	-6.0%	-5.4%
	Interior	0.2676	Interior	0.2591	Interior	0.2652	-0.9%	-3.2%	2.4%
1	Braga	0.2129	Braga	0.2263	Viana do Castelo	0.2348	-0.7%	-3.3%	2.6%
2	Viseu	0.2319	Viana do Castelo	0.2288	Braga	0.2358	10.8%	6.3%	4.2%
3	Viana do Castelo	0.2365	Viseu	0.2429	Setúbal	0.2428	-16.0%	-6.4%	-10.3%
4	Guarda	0.2404	Aveiro	0.2445	Lisboa	0.2431	-20.7%	-11.4%	-10.4%
5	Castelo Branco	0.2437	Castelo Branco	0.2508	*Açores*	0.2498	-12.1%	-9.4%	-3.0%
6	Aveiro	0.248	Guarda	0.2519	Coimbra	0.2504	-6.7%	-4.2%	-2.5%
7	Vila Real	0.2602	Coimbra	0.2569	Faro	0.2511	-16.4%	-11.4%	-5.7%
8	Leiria	0.2615	*Açores*	0.2576	*Madeira*	0.2517	-13.6%	-7.6%	-6.5%
9	Porto	0.2641	Vila Real	0.2588	Leiria	0.2527	-3.4%	-0.5%	-2.9%
10	Coimbra	0.2683	Porto	0.2598	Viseu	0.254	9.5%	4.7%	4.6%
11	Santarém	0.2737	Leiria	0.2602	Santarém	0.2552	-6.8%	-3.6%	-3.3%
12	Bragança	0.2816	Bragança	0.2626	Aveiro	0.2556	3.1%	-1.4%	4.5%
13	*Açores*	0.2843	Santarém	0.2638	Porto	0.2577	-2.4%	-1.6%	-0.8%
14	Setúbal	0.2892	Faro	0.2662	Castelo Branco	0.2643	8.5%	2.9%	5.4%
15	*Madeira*	0.2912	*Madeira*	0.2691	Évora	0.2657	-15.0%	-10.2%	-5.4%
16	Faro	0.3005	Setúbal	0.2708	Guarda	0.2687	11.8%	4.8%	6.7%
17	Lisboa	0.3064	Lisboa	0.2714	Portalegre	0.2688	-14.4%	-13.2%	-1.4%
18	Beja	0.3091	Portalegre	0.2726	Bragança	0.2697	-4.2%	-6.7%	2.7%
19	Évora	0.3127	Beja	0.2746	Beja	0.2708	-12.4%	-11.2%	-1.4%
20	Portalegre	0.3141	Évora	0.2809	Vila Real	0.2756	5.9%	-0.5%	6.5%
	Coefficient of variation	*10.9%*		*5.6%*		*4.6%*			
	Unweighted mean	*0.2715*		*0.2585*		*0.2559*			

TABLE 4 – Atkinson coefficient and Theil's first measure

Pos.	Atkinson Coefficient 1986		Atkinson Coefficient 1996		Atkinson Coefficient 2005		Growth rate 1986-2005	Theil measure 1986		Theil measure 1996		Theil measure 2005		Growth rate 1986-2005
	Portugal	**0.0777**	**Portugal**	**0.0614**	**Portugal**	**0.0552**	**-29.0%**	**Portugal**	**0.1567**	**Portugal**	**0.1228**	**Portugal**	**0.1076**	**-31.4%**
	Littoral	0.0775	Littoral	0.0614	Littoral	0.0545	-29.7%	Littoral	0.1565	Littoral	0.1227	Littoral	0.1061	-32.2%
	Interior	0.0752	Interior	0.0598	Interior	0.0595	-21.0%	Interior	0.1490	Interior	0.1204	Interior	0.1170	-21.5%
1	Braga	0.0546	V. do Castelo	0.0461	V. do Castelo	0.0465	-21.8%	Braga	0.1093	V. do Castelo	0.0933	V. do Castelo	0.0921	-23.0%
2	Viseu	0.0592	Braga	0.0481	Braga	0.0471	-13.7%	V. do Castelo	0.1196	Braga	0.0977	Braga	0.0939	-14.1%
3	V. do Castelo	0.0595	Viseu	0.0517	Setúbal	0.0519	-36.0%	Viseu	0.1200	Viseu	0.1058	Setúbal	0.0994	-38.4%
4	Cast. Branco	0.0645	Aveiro	0.0545	Coimbra	0.0524	-26.9%	Cast. Branco	0.1285	Aveiro	0.1099	Lisboa	0.1009	-38.8%
5	Guarda	0.0655	Cast. Branco	0.0561	Lisboa	0.0532	-35.8%	Aveiro	0.1323	Coimbra	0.1142	Coimbra	0.1031	-28.6%
6	Aveiro	0.0658	Guarda	0.0564	*Açores*	0.0538	-31.6%	Guarda	0.1333	Cast. Branco	0.1142	*Açores*	0.1046	-32.7%
7	Leiria	0.0700	Coimbra	0.0567	Leiria	0.0538	-23.2%	Leiria	0.1388	Guarda	0.1161	Leiria	0.1057	-23.9%
8	Porto	0.0708	*Açores*	0.0580	Viseu	0.0539	-8.9%	Vila Real	0.1422	*Açores*	0.1165	Faro	0.1067	-36.9%
9	Vila Real	0.0715	Porto	0.0587	Aveiro	0.0547	-16.9%	Porto	0.1444	Vila Real	0.1187	*Madeira*	0.1068	-35.3%
10	Coimbra	0.0717	Vila Real	0.0587	Porto	0.0552	-22.1%	Coimbra	0.1445	Porto	0.1191	Viseu	0.1072	-10.7%
11	Santarém	0.0771	Leiria	0.0596	Santarém	0.0557	-27.8%	Santarém	0.1526	Leiria	0.1194	Santarém	0.1084	-29.0%
12	*Açores*	0.0785	Bragança	0.0596	*Madeira*	0.0557	-33.6%	*Açores*	0.1555	Bragança	0.1195	Aveiro	0.1088	-17.8%
13	Bragança	0.0795	Santarém	0.0609	Faro	0.0560	-35.2%	Bragança	0.1584	Faro	0.1208	Porto	0.1094	-24.2%
14	Setúbal	0.0810	Faro	0.0616	Cast. Branco	0.0584	-9.5%	Setúbal	0.1613	Santarém	0.1218	Cast. Branco	0.1157	-9.9%
15	Lisboa	0.0829	Lisboa	0.0631	Guarda	0.0596	-9.0%	Lisboa	0.1648	Lisboa	0.1229	Évora	0.1180	-37.4%
16	*Madeira*	0.0839	Setúbal	0.0635	Évora	0.0608	-37.0%	*Madeira*	0.1651	Setúbal	0.1243	Guarda	0.1198	-10.1%
17	Faro	0.0865	*Madeira*	0.0637	Bragança	0.0615	-22.7%	Faro	0.1691	*Madeira*	0.1252	Bragança	0.1205	-23.9%
18	Beja	0.0949	Portalegre	0.0677	Portalegre	0.0616	-36.1%	Beja	0.1866	Portalegre	0.1333	Portalegre	0.1208	-35.3%
19	Portalegre	0.0964	Beja	0.0677	Beja	0.0637	-32.9%	Portalegre	0.1867	Beja	0.1342	Beja	0.1232	-34.0%
20	Évoraa	0.0965	Évora	0.0716	Vila Real	0.0651	-8.9%	Évora	0.1884	Évora	0.1411	Vila Real	0.1268	-10.8%
	Coefficient of variation	*16.4%*		*10.7%*		*8.9%*			*15.3%*		*9.6%*		*8.8%*	
	Unweighted mean	*0.0755*		*0.0592*		*0.0560*			*0.1501*		*0.1184*		*0.1096*	

Figure 2 – Comparison between Braga and some selected regions (Lorenz curves)



Notes: The dotted Lorenz curve in each graphic corresponds to Braga. The other regions (solid lines) are, by order of appearance in the graphics from left to right, Santarém, Beja, Lisboa, Faro, Portalegre and Açores.

third quartile and 12 years in the ninth decile. Analysing in addition the quantile ratios, Braga presents the lowest value (1.5) and Lisboa the highest (3) with respect to the ratio Q90/Q50, while all the other 18 regions display the same value (2.25). In summary, Braga is the least unequal region in part due to a very compressed distribution for low values of education (i.e. the individuals are equally poor), whereas Lisboa is more unequal due to a higher share of population with higher schooling levels, which leads to a more stretched top (i.e. the individuals are unequal due to high schooling levels at the top).

TABLE 5 – Quantiles and quantile ratios

	1986									1996									2005								
	Q10	Q25	Median	Q75	Q90	Q/90/ Q50	Q50/ Q10	Q90/ Q10	Q75 Q25	Q10	Q25	Median	Q75	Q90	Q/90/ Q50	Q50/ Q10	Q90/ Q10	Q75 Q25	Q10	Q25	Median	Q75	Q90	Q/90/ Q50	Q50/ Q10	Q90/ Q10	Q75 Q25
Portugal	**4**	**4**	**4**	**6**	**9**	**2.25**	**1**	**2.25**	**1.5**	**4**	**4**	**6**	**9**	**12**	**2**	**1.5**	**3**	**2.25**	**4**	**4**	**6**	**12**	**12**	**2**	**1.5**	**3**	**3**
Interior	1	4	4	6	9	2.25	4	9	1.5	4	4	4	9	12	3	1	3	2.25	4	4	6	9	12	2	1.5	3	2.25
Littoral	4	4	4	6	9	2.25	1	2.25	1.5	4	4	6	9	12	2	1.5	3	2.25	4	4	6	12	12	2	1.5	3	3
Aveiro	4	4	4	6	9	2.25	1	2.25	1.5	4	4	6	6	12	2	1.50	3	1.5	4	4	6	9	12	2	1.5	3	2.25
Beja	1	4	4	6	9	2.25	4	9	1.5	4	4	4	9	12	3	1	3	2.25	4	4	6	9	12	2	1.5	3	2.25
Braga	4	4	4	6	6	1.5	1	1.5	1.5	4	4	6	6	9	1.5	1.5	2.25	1.5	4	4	6	9	12	2	1.5	3	2.25
Bragança	1	4	4	6	9	2.25	4	9	1.5	4	4	6	9	12	2	1.5	3	2.25	4	4	6	9	12	2	1.5	3	2.25
Cast. Branco	4	4	4	6	9	2.25	1	2.25	1.5	4	4	4	6	12	3	1	3	1.5	4	4	6	9	12	2	1.5	3	2.25
Coimbra	4	4	4	6	9	2.25	1	2.25	1.5	4	4	6	9	12	2	1.5	3	2.25	4	4	6	9	12	2	1.5	3	2.25
Évora	1	4	4	6	9	2.25	4	9	1.5	4	4	4	9	12	3	1	3	2.25	4	4	6	9	12	2	1.5	3	2.25
Faro	1	4	4	6	9	2.25	4	9	1.5	4	4	6	9	12	2	1.5	3	2.25	4	4	9	12	12	1.33	2.25	3	3
Guarda	4	4	4	4	9	2.25	1	2.25	1	4	4	4	6	12	3	1	3	1.5	4	4	6	9	12	2	1.5	3	2.25
Leiria	4	4	4	6	9	2.25	1	2.25	1.5	4	4	6	9	12	2	1.5	3	2.25	4	4	6	9	12	2	1.5	3	2.25
Lisboa	4	4	4	9	12	3	1	3	2.25	4	4	6	12	12	2	1.5	3	3	4	6	9	12	12	1.33	2.25	3	2
Portalegre	1	4	4	6	9	2.25	4	9	1.5	4	4	4	9	12	3	1	3	2.25	4	4	6	9	12	2	1.5	3	2.25
Porto	4	4	4	6	9	2.25	1	2.25	1.5	4	4	6	9	12	2	1.5	3	2.25	4	4	6	9	12	2	1.5	3	2.25
Santarém	1	4	4	6	9	2.25	4	9	1.5	4	4	6	9	12	2	1.5	3	2.25	4	4	6	9	12	2	1.5	3	2.25
Setúbal	1	4	4	6	9	2.25	4	9	1.5	4	4	6	9	12	2	1.5	3	2.25	4	4	9	12	12	1.33	2.25	3	3
Viana Castelo	4	4	4	6	9	2.25	1	2.25	1.5	4	4	6	6	12	2	1.5	3	1.5	4	6	6	9	12	2	1.5	3	1.5
Vila Real	1	4	4	6	9	2.25	4	9	1.5	4	4	4	9	12	3	1	3	2.25	4	4	6	9	12	2	1.5	3	2.25
Viseu	4	4	4	6	9	2.25	1	2.25	1.5	4	4	6	6	12	2	1.5	3	1.5	4	4	6	9	12	2	1.5	3	2.25
Madeira	1	4	4	6	9	2.25	4	9	1.5	4	4	6	9	12	2	1.5	3	2.25	4	4	6	9	12	2	1.5	3	2.25
Açores	1	4	4	6	9	2.25	4	9	1.5	4	4	6	9	12	2	1.5	3	2.25	4	4	6	9	12	2	1.5	3	2.25

Notes: Q10, Q25, Q75, and Q90 denote the 1st decile, the 1st quartile, the 3rd quartile and the 9th decile, respectively.

(ii) The 1996 cross-section

Average years of schooling of the Portuguese workforce in 1996 was 6.59, which represents an important increase in the level of education from 1986. Braga and Lisboa maintained their positions as the regions with, respectively, the lowest and the highest level of schooling at 5.74 and 7.60 years. The other regions exhibited a very similar upward trend in schooling.

As shown in Tables 3 and 4, all selected inequality measures are lower in 1996 than in 1986 for most regions. Braga and Lisboa are at the top and the bottom positions, respectively, with a Gini coefficient of 0.2263 in the former region, and 0.2714 in the latter. Again, considering the three inequality indices, the ranking of the regions is not exactly the same, not even at the top positions, with Braga and Viana do Castelo exchanging the first position depending on the selected inequality index. One important feature is that, irrespective of the selected index, inter-regional dispersion in 1996 is smaller than in 1986. In particular, the inter-regional dispersion for the Gini coefficient reduced to half, from 10.9% to 5.6%.

Looking at the shape of the distributions (see Table 5), we conclude that Braga and Lisboa still present a very similar distribution up to the median. Differences are more visible in the second half of the distribution: Braga displays a compressed top with schooling levels close to those of the first half of the distribution, while the distribution of Lisboa has a clear stretched top. This conclusion is also supported by the fact that the ratio Q50/Q10 is the same for Lisboa and Braga while the ratio Q90/Q50 is higher in Lisboa.

(iii) The 2005 cross-section

The level of education of the Portuguese workforce kept its upward trend between 1996 and 2005. For the entire country, average years of schooling is 7.8, while in Lisboa is 8.71 years, and in Braga 7.04 years. Meanwhile, inter-regional dispersion continues to narrow, since the coefficient of variation was 5.03%, considering all regions (3.51% ignoring Lisboa).

Most regions also show a reduction in inequality (see Tables 3 and 4). Viana do Castelo was, in all cases, the least unequal region, whereas Vila Real is in the last position, showing a considerable increase in inequality over the 1986-2005 period. Despite different trends among regions, in 2005 inter-regional dispersion with respect to inequality is visibly smaller than in 1986 – the coefficient of variation for all the three inequality measures is smaller in 2005 than in 1986.

(iv) Education inequality over the period 1986-2005

The main conclusion from the previous analysis is that the level of education is steadly increasing while, at the same time, for the majority of the Portuguese regions, there is an unambiguous decrease in within-region education inequality.

One interesting aspect can also be identified by looking at the changes in the inequality ranking over the period 1986-2005. In the first year under analysis, 1986, the top positions of the inequality ranking (more equal regions) were occupied by both *litoral*[12] and *interior*[13] regions indistinctly, and the same applies to the bottom positions. In 2005, on the contrary, only one *interior* region, Viseu, appears in the top positions, which implies that the *litoral* regions became the least unequal and also exhibit higher levels of education. The *interior* regions became the most unequal regions, with the lowest educational attainment[14].

A second feature observed is that the regions that started with higher initial levels of education are the ones that exhibit a decrease in education inequality, whereas the regions that started with

12 The following ten *Distritos* located near the coastline are classified as *litoral*: Aveiro, Braga, Coimbra, Faro, Leiria, Lisboa, Porto, Santarém, Setúbal, Viana do Castelo.
13 The following eigth, landlocked *Distritos* are classified as *interior*: Beja, Bragança, Castelo Branco, Évora, Guarda, Portalegre, Vila Real, Viseu.
14 Only Viseu is in the top-ten positions in the inequality rankings for the various years. Bragança is the tenth education-richest region in 2005.

a lower schooling level recorded increases in inequality. This interesting empirical result suggests that the relationship between the education level and education inequality can indeed be close to an inverted-U shape. We investigate this issue in the next section.

(v) The Kuznets curve of education

The process of increasing the level of education will tend to produce an inverted-U-shaped evolution of education inequality. Each region/country starts from a situation characterised by a low level of education, in which the large majority of the population has a very low level of education. Therefore, the distribution will be considerably compressed around the lowest levels of education[15]. As the level of education rises, particularly through the access of young cohorts to higher levels of education, the result is a stretching of the top end of the distribution, which will lead to an increase in education inequality. This intermediate situation reflects a dualistic structure, with two main groups: (i) a large group with low levels of education; and (ii) a small, but growing group with medium to high levels of education. In a third stage, as an increasing share of the population obtains higher levels of education, there will be a shifting of the distribution to the right. Education distribution is thus expected to return to its initial compressed shape, but now around high levels of education. In this final stage there will be a homogeneous and highly educated population.

In contrast to the original Kuznets curve, which is based on the idea of inter-sectoral shifts, our framework reflects mainly inter-generational changes. Since we are using years of schooling as our proxy for education, the individual level of education can be considered rather fixed. Therefore, changes in the level of education of the workforce in a certain economy emerge mainly via inter-generational forces.

(v.1) The empirical model

We will test two main hypothesis:

- hypothesis 1: the regions with a higher initial level of education (i.e. above a certain threshold) tend to have a decrease in education inequality, whereas the poor regions tend to have an increase in inequality;
- hypothesis 2: the relationship between the level of education and education inequality has an inverted-U shape.

Accordingly, the regressions to be estimated are the following:

$$\Delta X_i = \beta_0 + \beta_1 H_{i,1986} + \mathrm{u}_i \qquad (1)$$

$$X_{it} = \beta_0 + \beta_1 H_{it} + \mathrm{u}_{it} \qquad (2)$$

$$X_{it} = \beta_0 + \beta_1 H_{it} + \beta_2 + H_{it}^2 + \mathrm{u}_{it} \qquad (3)$$

where X_{it} and $\Delta X_{i,t}$ are, respectively, the level and the variation in education inequality between 1986 and 2005, H_{it} is the level of education given by the average years of schooling, α_i is the

15 The usual assumption, when measuring the stock of human capital, concerning the most basic level of education is that the individuals that have not completed primary education (a 4-year cycle) have one year of schooling, instead of zero years, since even when an individual has no formal education there is a minimum level of human capital, which is acquired through informal education and on-the-job training, for instance. We follow this specification, also known as the nonzero specification/hypothesis, which may influence our conclusions, since when the average education level is very low, education inequality will also be very low, as all the population will have a very similar education level given our lower bound (one year of schooling).

fixed effects component, i is the geographic unit (the eighteen *Distritos* plus the two insular regions in the complete sample[16]), and t is a time index, t = 1986, 1996, 2005.

Equation (1) gives the relationship between the initial level of education and the change in education inequality. In particular, it explains the change in inequality as a function of the beginning period level of education. Equation (2) tests a linear specification for the contemporaneous relationship between the level of education and inequality, while equation (3) tests the quadratic specification. The first model uses a single data point; models (2) and (3) use panel data for the 20 regions and three data points.

The results are presented in Tables 6 and 7. As we can see, there is a statistically significant negative relationship between the initial level of education and the change in inequality (column (a)). Each additional year of schooling in 1986 reduced the Gini coefficient by 14 percentage points for the period 1986-2005. Excluding Alentejo and Lisboa, the magnitude of the effect for this restricted sample triplicates to a value of 41 percent (column (c))[17].

TABLE 6 – Regression of the evolution of education inequality on the initial level of education

Dependent variable Sample	$\Delta X_{i,\,1986\text{-}2005}$ Full	$\Delta X_{i,\,1986\text{-}2005}$ Without Alentejo	$\Delta X_{i,\,1986\text{-}2005}$ Without Alentejo and Lisboa	$\Delta X_{i,\,1986\text{-}1996}$ Full	$\Delta X_{i,\,1986\text{-}1996}$ Without Alentejo	$\Delta X_{i,\,1986\text{-}1996}$ Without Alentejo and Lisboa
	(a)	(b)	(c)	(d)	(e)	(f)
Constant	0.661316**	1.04128***	2.03402***	0.263922	0.518782***	1.07598***
	(2.2793)	(4.2949)	(5.4156)	(1.4528)	(3.7739)	(5.0183)
$H_{i,86}$	-0.139739**	-0.209132***	-0.406692***	-0.0602908	-0.106801***	-0.217686***
	(-2.4497)	(-4.4357)	(-5.4741)	(-1.6881)	(-3.9951)	(-5.1326)
Number of observations	20	17	16	20	17	16
R^2	0.250029	0.567415	0.681570	0.136671	0.515519	0.652981

Notes: OLS estimations of model (1). t-statistics are in parentheses. *, ** and *** mean significance at the level of 10%, 5% and 1%, respectively.

As far as the shape of the evolution of education inequality is concerned (see table 7 and Figure 3), our results suggest an inverted-U curve. In model (2), columns (g)-(h), the coefficient is negative and statistically significant, revealing a negative relationship between the level of education and education inequality (using the Gini index). Despite the statistical significance and the large value of R^2, the coefficient of schooling is quite small (the value for the full sample is -0.0065, which means that an increase in average schooling by one year leads to a decrease in the Gini coefficient by only 0.0065 – column (g)). In model (3), we obtain the expected signs for the coefficients on the level of education and its square, but for the full sample the coefficients are not statistically significant (column (i)). However, leaving Alentejo out of the sample, the coefficients become statistically significant (column (j)). Moreover, the results are sensitive to the initial year of the sample, since after eliminating the observations for 1986 the absolute values of the coefficients more than triplicate and the R^2 reaches almost 90% (column (k)).

One important implication of these results is that we can establish a threshold which separates two main groups of regions: those in which we observe an increase and those in which there is a

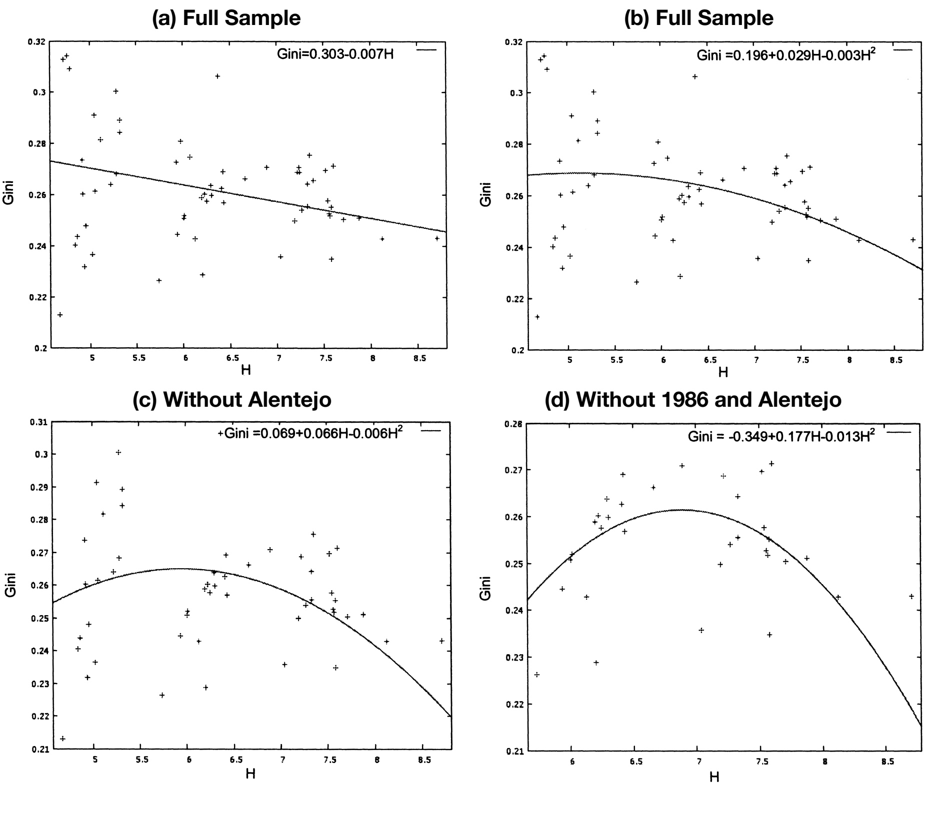
16 Lisboa is manifestly an outlier, as it presents very high levels of average years of schooling relative to all the other regions, although the differences have narrowed over the sample years. We thus exclude Lisboa from the sample in some of the estimations.
17 The results are robust to changes in the inequality measure used. For instance, the estimated coefficient for the full sample when using the Atkinson index is -0.105, but not statistically significant. The use of the Theil measure leads to a statistically significant coefficient of -0.121.

TABLE 7 – The education inequality curve

Dependent variable Sample	$X_{i,t}$ Full	$X_{i,t}$ Without Alentejo	$X_{i,t}$ Full	$X_{i,t}$ Without Alentejo	$X_{i,t}$ Without 1986 and Alentejo
	(g)	**(h)**	**(i)**	**(j)**	**(k)**
Constant	0.302901***	0.286239***	0.195648**	0.0694279	-0.349125***
	(24.8751)	(22.0821)	(2.6063)	(0.9551)	(-3.2677)
$H_{i,t}$	-0.0065028***	-0.00447848**	0.0285482	0.0657605***	0.177355***
	(-3.4025)	(-2.2178)	(1.1753)	(2.8201)	(5.7144)
$H^2_{i,t}$			-0.00278169	-0.00552911***	-0.012879***
			(-1.4474)	(-3.0213)	(-5.7597)
Number of observations	60	51	60	51	34
R^2	0.671967	0.599569	0.689107	0.688442	0.889366

Notes: Fixed effects estimations of models (2) and (3). t-statistics are in parentheses. *, ** and *** mean significance at the level of 10%, 5% and 1%, respectively.

Figure 3 – Returns to schooling in selected developed countries



decrease in inequality. Taking into account the full sample (60 observations) the threshold is estimated in 5.13 schooling years and when ignoring Alentejo (51 observations) the threshold becomes equal to 5.95 years of schooling.

4. Concluding remarks

The capacity of a country to create *new things and ideas* (innovation) and/or its ability to absorb and adapt to *new knowledge and technologies* (imitation) is a major determinant of its economic performance. Both innovation and imitation activities require a workforce endowed with a high stock of human capital. The importance of human capital thus calls for a more thorough analysis of its level and distribution.

In this paper, we investigated the distribution of human capital acquired through formal education in Portugal in great detail, filling a gap in the literature. Although Portugal still presents a low average level of education relative to other developed countries, our paper confirms the increase in average years of schooling of the workforce reported in previous studies, from 5.46 years in 1986 to 7.81 years in 2005. We also found a downward trend in education inequality for Portugal, with the Gini coefficient decreasing from 0.284 in 1986 to 0.255 in 2005, and the Atkinson coefficient and the Theil measure decreasing by 29% and 31%, respectively. Generally speaking, the decrease in the values of the three indices suggests: (i) a more equal distribution of education; (ii) lower inequality at the top end of the distribution; and (iii) lower inequality at the bottom end of the distribution, the latter indicating that a higher share of population is gaining access to intermediate and high educational levels.

We also tested whether the relationship between the level of education and education inequality during the process of increasing average education would be close to an inverted-U. The process of human capital accumulation (through formal education) can lead to an increase in education inequality, at initial and intermediate stages, and only after a certain threshold will education inequality start to decrease. The stretching of the top end of the distribution at initial stages is responsible for the increase in inequality, whilst the subsequent compression of the distribution around higher levels of education will force inequality to decrease. We found that the initially relatively high educated regions were those that experienced decreases in inequality, whereas the initially relatively poor educated regions show an opposite shift, with the threshold that separates the two groups of regions occurring at 5.13 years of schooling in the full sample. This result highlights the importance of public policies addressing education, since investments in education, besides all other positive impacts, will lead to a reduction in education inequality, after a certain threshold. This can transmit to a reduction in earnings inequality and, later, in income inequality, demanding less redistribution from the state.

Our results can also help to explain the evolution of earnings inequality in the Portuguese economy reported in previous studies. The majority of the studies have associated the increase in earnings inequality with the increase in schooling levels and have observed that this increasing inequality is related to a stretching of the top end of the distribution. Since we have shown that for some regions there was indeed an increase in education inequality this could have fostered between-group earnings inequality. However, the main impact resulted from the stretching of the top of education distribution that most regions have experienced, which might have spurred the referred stretching of the top end of the earnings distribution. Nevertheless, one should expect a future decrease in between-group earnings inequality as the continuing increase in the level of education will supposedly lead to a compression of its distribution and a reduction of its inequality (a process still occurring). Lisboa, Setúbal and Faro are the most advanced districts in this process since the top end of the respective distributions have become increasingly compressed (for instance, in the last year of the analysis, Q75 and Q90 display the exact same value). Consistent with our claims, these three districts were the ones that presented the highest decreases in education inequality, measured by the Gini coefficient.

The evidence presented in this paper is of special interest to future studies investigating the impact of inequality on growth in Portugal: assessing the direct impact of education (or human capital) inequality on growth or using it as a control variable when analysing the influence of income (earnings) inequality on growth. Nevertheless, some drawbacks of the analysis must be taken into consideration and addressed in future research: the high level of disaggregation leads us to capture very specific regional characteristics that enrich our analysis but may bias our results; and our data excludes a large group of the Portuguese workforce, public administration workers, which can potentially bias our estimations.

Further research on the subject should include the measurement of human capital inequality considering a Mincerian specification, as previous studies have found evidence that even if educational attainment is an accurate proxy of the human capital stock, using education inequality as a proxy for human capital inequality can be misleading (see e.g. Lim and Tang, 2008). Furthermore, empirical studies regarding the relationship between education or human capital inequality and earnings inequality for Portugal are needed to test whether or not the impact is positive, as expected.

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Appendix A

TABLE A.1 – Inequality indices and definitions

Inequality index	Definition
Gini index	$G = 1 + \left(\frac{1}{n}\right) - \left(\frac{2}{n2\,\mu}\right) \sum_{i=1}^{n} (n - i + 1)h_i$
Atkinson index (with ε=0.5)	$A = 1 - \left(\frac{1}{n}\right)\left[\left(\frac{1}{n}\right) \sum_{i=1}^{n} (h_i^{1-\varepsilon})\right]^{\frac{1}{1-\varepsilon}} \quad , \varepsilon = 0.5$
Theil's first measure	$T = \left(\frac{1}{n}\right) \sum_{i=1}^{n} \left(\frac{h_i}{\mu}\right) ln \left(\frac{h_i}{\mu}\right)$

Notes: h_i represents years of schooling of individual i, n is the population, μ is the average education level, ε is the Atkinson parameter for inequality aversion, and $0<h_1<h_2<\ldots<h_n$.

Appendix B

QP provides information on the highest schooling level completed by each worker, according to the six levels presented in Table B.1 below. The level of education of each worker corresponds to the assumed cumulated duration in years of the highest schooling level she/he has completed.

TABLE B.1 – Schooling levels classification

Level	Definition	Assumed cumulated duration in years
H0	Less than Basic 1st cycle[18]	1
H1	Basic 1st cycle	4
H2	Basic 2nd cycle	6
H3	Basic 3rd cycle	9
H4	Secondary schooling	12
H5	Higher education, 1st cycle (*Bacharelato*)	15
H6	Higher education, 2nd cycle (*Licenciatura*)	17

Following the assumed correspondence between schooling years and each schooling level, we can compute the average years of schooling of the workforce employed in geographic unit *i* at time *t*, as

$$H_{it} = \frac{1x\sum_{j=1}^{17} L_{ijtH0} + 4x\sum_{j=1}^{17} L_{ijtH1} + 6x\sum_{j=1}^{17} L_{ijtH2} + 9x\sum_{j=1}^{17} L_{ijtH3} + 12\sum_{j=1}^{17} L_{ijtH4} + 15\sum_{j=1}^{17} L_{ijtH5} + 17\sum_{j=1}^{17} L_{ijtH6}}{\sum_{j=1}^{17} L_{ijt}}$$

where H0-H6 are the schooling levels, *i* (geographic unit)=1,...,20; *j* (CAE)=1,...17 (in 1986 there are only 9 sectors); *t* (year)=1986, 1996 and 2005;
L_{ijts} = number of workers in geographic unit *i* and sector *j* at time *t* for which *s* (H0-H6) is the highest schooling level completed. For instance, L_{ijtH4} is the number of workers in geographic unit *i* and sector *j* at time *t* for which H4 is the highest schooling level completed.

18 In 2005, the description for H0 is 'Cannot read or write'.

On the Empirical Separability of News Shocks and Sunspots*

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abstract

In this note we discuss the possibility of empirically evaluating the relative importance of different drivers of forecast errors in linear rational expectations frameworks, using the predictions generated by the theory. By means of a few simple examples, we show that, when accounting for indeterminate equilibria, empirical difficulties are likely to arise in distinguishing between determinate models driven by news shocks or rather by indeterminate ones under non-fundamental – or arbitrarily related to fundamentals – sunspot noise.

JEL Classification: C1; E3

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1. Introduction

Identification issues in dynamic stochastic systems under rational expectations (RE) have long been recognized in the macroeconometric literature (e.g., Rothenberg, 1971; Sims, 1980; Pesaran, 1987). Previous studies have focused on the fundamental problem in estimating structural RE models which stems from the presence of unobservable components (e.g., Chow, 1980; Hansen and Sargent, 1980). More recently, there has been a growing interest in the possibility of identifying and estimating multiple equilibria models, with several studies showing that the success in distinguishing between determinate and indeterminate frameworks is likely to hinge on untestable restrictions about the dynamic structure of the underlying model (e.g., Kamihigashi, 1996; Beyer and Farmer, 2007, 2008). The striking implications of such problem for policy making are straightforward, since indeterminate equilibrium economies are subject to extrinsic uncertainty or arbitrarily (via indeterminacy) amplified shocks to fundamentals (e.g., Azariadis, 1981; Benhabib and Farmer, 1999), which contribute to the variance of aggregate fluctuations and thus affect the welfare of risk-averse agents. The use of empirical investigations to provide well-founded recommendations, intended to prevent policy actions from generating indeterminacy, has therefore gained a central role in the macroeconomic policy analysis.

In this respect, the rising literature on news shocks (e.g., Cochrane, 1994; Beaudry and Portier, 2004, 2006; Jaimovich and Rebelo, 2009) – which views advance information on shifts in fundamentals or perceptions of incoming developments in the economy as important drivers of economic cycles – has partly addressed the issue of whether news-driven expectations revisions differ from beliefs shocks due to extrinsic uncertainty or sunspots. On an analytical level, it has been indeed demonstrated that the two types of shocks generally involve different cross-equation restrictions and implications for the dynamic properties of equilibria (Karnizova, 2007, 2010), and that models in which sunspots are able to generate business cycle comovements may well fail to do so under news shocks (Wang, 2007). A subsequent key research step appears then to be the extension of these results to econometric issues, notably to the analysis of whether stochastic systems driven by news shocks can be empirically distinguished from ones which allow for sunspots.

In this note, we make a first step toward examining the possibility of deciding on an econometric basis whether actually observed data are generated by determinate models driven by news shocks or rather by indeterminate equilibrium ones under non-fundamental – or arbitrarily related to current fundamentals – shocks (sunspot noise)[1]. While the possibility of obtaining closely matched dynamics for the observed variables results from the non-uniqueness of the responses to news shocks in the indeterminacy region (Karnizova, 2007), we show that a more subtle identification failure may obtain, which arises from the potential inability to distinguish between models subject to different sources of expectations errors.

Such an investigation avenue might also serve as a robustness exercise for studies on indeterminacy testing (e.g., Lubik and Schorfheide, 2004), which exploit information on autocovariance patterns of observed data to deliver evidence on determinacy versus indeterminacy, as long as under the latter fewer autoregressive roots of the underlying system are suppressed. While serial correlation is interpreted accordingly as favouring indeterminacy, enhanced time series properties could still be reproduced with parameters from the determinacy region when news shocks are present, as they are typically associated with endogenous propagation (Fève *et al.*, 2009).

1 We are therefore not concerned with the identification per se of news shocks (e.g., Beaudry and Portier, 2006). In a seminal contribution, Leeper *et al.* (2008) develop several theoretical examples of (fiscal) foresight which show that (full) anticipation produces equilibrium time series with a non-invertible moving average (MA) component, which has the effect of misaligning the agents' and the econometrician's information sets in estimated vector autoregressive (VAR) models. This problem in turn may involve serious distortions in many of the inferences (e.g., impulse response functions, Granger-causality) drawn from empirical analysis.

The remaining paper is organized as follows. In Section 2 we derive the full set of solutions to a general multivariate linear RE model under news shocks, following Karnizova (2007). In Section 3, several examples of observational equivalence between models driven by news shocks and sunspots are provided. Section 4 concludes.

2. The general solution of linear RE models under news shocks

In what follows, we briefly derive the reduced form solution for a general linear RE model expressed in Sims (2002) canonical form. This representation proves particularly convenient for our purposes in three dimensions: (i) it exploits the notion of rational forecast errors as a solution device, without constraining the underlying model to fulfil exogenously imposed regularity conditions; (ii) it permits the analysis of the role of news shocks as drivers of a learning (expectations revision) process, possibly in non-regular economies (Karnizova, 2007); (iii) it enables us to readily compare and confront two different types of shocks which can happen to influence the dynamic evolution of economic variables through rational forecast errors, namely news and sunspot shocks.

To begin with, we introduce the canonical form of linear RE models as considered in Sims (2002):

$$\Gamma_0 y_t = \Gamma_1 y_{t-1} + \Psi z_t + \Pi \eta_t, \qquad y_0 = \bar{y}, \qquad t \geq 1 \tag{1}$$

where $y_t' = (y_{1,t}'\ y_{2,t}'\ E_t(y_{2,t+1}))$ is a n-dimensional, $\Im_t$-measurable state vector consisting of $\hat{n}+k$ endogenous variables – collected in $y_{1,t}$ and $y_{2,t}$, respectively – and k (endogenously determined) conditional expectations $E_t(y_{2,t}) \equiv E_t(y_{2,t} \mid \Im_t)$, with $\Im_t$ denoting the filtration generated by system (1); z_t is an l-dimensional exogenously evolving (possibly serially correlated) random process while η represents a k x 1 vector of forecast errors satisfying $E_{t-1}(\eta_t) = 0$.

Let us consider a simple first-order autoregressive (AR) driving process for z_t:

$$z_t = \Phi z_{t-1} + v_t, \qquad v_t \sim N(0, \Sigma_v) \tag{2}$$

where the square invertible matrix $\Phi_{l \times l}$ is assumed to be stable, i.e. all its roots lie inside the unit circle. One possible avenue for modelling (imperfect) anticipation is to assume an information structure under which (noisy) news on the fundamental shock are disclosed as signals, which in turn allow economic agents to gather some information about incoming innovations to the exogenous variables by solving a signal extraction program[2]. Specifically, in every period agents are allowed to observe, in addition to current (and past) realizations of v_t, an exogenous stationary sequence $\{s_t^j\}$ as part of an information flow on the $j \geq 1$ periods ahead disturbances v_{t+j}:

$$s_t^j = v_{t+j} + u_t, \qquad u_t \sim N(0, \Sigma_u) \tag{3}$$

with u_t independent of v_t. The optimal (minimum mean square error) predictor is thus in the form[3]:

$$E_t(v_{t+i}) = \Sigma_v \Sigma_s^{-1} s_{t+i-j} \qquad \text{if} \quad i \leq j \tag{4}$$

As shown in Karnizova (2007), an innovation representation for linear stochastic models under news shocks can be derived to directly exploit the computational tools developed in Sims (2002) and further extended in Lubik and Schorfheide (2003) to account for multiple equilibria

2 For a thorough discussion of the analytical procedures involved, the reader is referred to the excellent book by Karnizova (2010).
3 Note that here the conditioning information set is larger than the filtration $\Im_t$.

frameworks. Indeed, under RE and observability of current realizations of v_t, the arrival of news on future fundamental impulses will create room for a recursive (rational) updating process of agents' beliefs, which can be specified as one-step ahead expectations revisions over a maximum anticipation horizon J $(0 < J < \infty)$:

$$\begin{aligned} E_t(v_t) \equiv v_t &= E_{t-1}(v_t) + \phi_t^0 \\ E_t(v_{t+i}) &= E_{t-1}(v_{t+i}) + \phi_t^i, \qquad i = 1,2,\cdots, J-1 \\ E_t(v_{t+J}) &= \phi_t^J \end{aligned} \tag{5}$$

or in a more compact form:

$$\begin{pmatrix} v_t \\ E_t(v_{t+1}) \\ \vdots \\ E_t(v_{t+J}) \end{pmatrix} = \begin{pmatrix} E_{t-1}(v_t) \\ \vdots \\ E_{t-1}(v_{t-1+J}) \\ 0 \end{pmatrix} + \phi_t \tag{6}$$

all vectors being of dimensions $(l + Jl)$ x 1. The consolidated stochastic law of motion for both the random process z_t and the conditional forecasts $E_t\,(v_{t+i})$ is indeed shown to have the expectations revisions ϕ_t as the common driving force, yielding the following augmented system[4]:

$$\widetilde{\Gamma}_0 \widetilde{y}_t = \widetilde{\Gamma}_1 \widetilde{y}_{t-1} + \widetilde{\Psi}\phi_t + \widetilde{\Pi}\eta_t, \qquad t \geq 1 \tag{7}$$

with the $(n + l + Jl)$ x 1 vector $\widetilde{y}_t$ including all the endogenous variables, the serially correlated exogenous variables z_t and the conditional (rational) expectations on future realizations of fundamental impulses v_t. Since model (7) is in Sims (2002) canonical form, we can directly apply his solution procedure to derive the equilibrium reduced form representation.

Let ζ_t be a *p*-dimensional vector of sunspot shocks with $E_{t-1}\,(\zeta_t) = 0$, and assume that forecast errors η_t can be expressed as a linear combination of fundamental shocks and sunspot variables, i.e. $\eta_t = A_1\phi_t + A_2\zeta_t$, with the (time-invariant) impact matrices $A_{1k\times(l+Jl)}$ and $A_{2k\times p}$ to be determined. The solution algorithm developed in Sims (2002) and extended in Lubik and Schorfheide (2003) indeed delivers a mapping from the shocks impinging on the system to the endogenous expectation errors, under which stability of equilibrium paths is guaranteed. The full set of solutions for the latter is then derived as follows[5]:

$$\eta_t = [-\Lambda + V_{\tilde{\Pi},2} M_1]\phi_t + V_{\tilde{\Pi},2}\zeta_t^* \tag{8}$$

where $\zeta_t \equiv M_2\zeta_t$ is regarded as a reduced form sunspot shock, Λ is the real matrix stemming from the existence condition and consisting of the structural parameters of the model as well as the matrix $V_{\tilde{\Pi},2}$, which by construction is empty whenever the equilibrium is determinate[6]. As demonstrated in Lubik and Schorfheide (2003), not all the reduced form parameters are uniquely determined, since the elements of the matrix pair (M_1, M_2) are unrestricted.

4 See Appendix A.
5 Once this is at hand, the evolution of the endogenous variables can be obtained by substituting back into the model or exploiting the k dummy equations $y_{2,t} = E_{t-1}\,(y_{2,t}) + \eta_t$.
6 That is, when the number of restrictions on η_t imposed by the unstable components of the dynamic system (7) is equal to the dimension k of the former.

3. News versus sunspot shocks

Assume that an econometrician were to be confronted with time series data $\{y_t^o\}$ exhibiting high volatility and persistence, so that he might arguably conjecture that such dynamic properties shall be ascribed to the presence of anticipated shocks to fundamentals (e.g., Fève *et al.*, 2009). In what follows, we provide a series of simple examples pointing out that such conjecture may happen to be incorrectly validated by empirical exercises when observational equivalence arises between stochastic linear models featuring different drivers of rational forecast errors. This in turn casts some doubt on the possibility of learning from real world data whether they have been generated under determinacy or indeterminacy.

Example 1 – Consider the prototypical New Keynesian monetary DSGE model (e.g., King, 2000) summarized by the following equations:

$$x_t = E_t(x_{t+1}) - \tau[R_t - E_t(\pi_{t+1})], \qquad \tau > 0 \tag{i}$$

$$\pi_t = \beta E_t(\pi_{t+1}) + \kappa x_t, \qquad \beta \in (0,1), \quad k > 0 \tag{ii}$$

$$R_t = \psi \pi_t + v_t, \qquad v_t \sim N(0, \sigma_v^2) \tag{iii}$$

$$v_t = \phi_t^0 + \phi_{t-1}^1 \tag{iv}$$

The aggregate demand equation (i) can be derived from dynamic utility maximization, whereas the expectational Phillips schedule (ii) under sticky prices governs inflation dynamics. The system is augmented with a monetary policy (interest rate) rule (iii)[7] and a decomposition (iv) of the monetary shock – the unique source of aggregate uncertainty in the economy – into a pure innovation and a component which is subject to one-period noisy learning under the signal-based information structure described in Section 2.

Thus, at each date t the vector of expectations revisions generated by the solution of the signal extraction problem consists of an unanticipated impulse $\phi_t^o \equiv v_t - E_{t-1}(v_t) = (1-\Theta)v_t - \Theta u_{t-1}$ and an expectation revision $\phi_t^1 \equiv E_t(v_{t+1}) = \Theta(v_{t+1} + u_t)$, with $\Theta = \sigma_v^2(\sigma_v^2 + \sigma_u^2)^{-1}$.

Let $y_t' = (x_t\ \pi_t\ v_t\ E_t(x_{t+1})\ \ E_t(\pi_{t+1})\ \ E_t(v_{t+1}))$ be the vector of states, $\phi_t' = (\phi_t^o\ \ \phi_t^1)$ the vector of exogenous and serially uncorrelated disturbances[8], and define forecast errors $\eta_t' = (\eta_t^x\ \eta_t^\pi)$ such that $\eta_t^x = x_t - E_{t-1}(x_t)$ and $\eta_t^\pi = \pi_t - E_{t-1}(\pi_t)$. Then, the equations (i)-(iv) can be cast in Sims (2002) canonical form[9]:

$$\Gamma_0(\theta)y_t = \Gamma_1(\theta)y_{t-1} + \Psi(\theta)\phi_t + \Pi(\theta)\eta_t, \tag{9}$$

where , $\Gamma_0(\theta)_{6x6}$, $\Gamma_1(\theta)_{6x6}$, $\psi(\theta)_{6x2}$ and $\Pi(\theta)_{6x2}$ are matrices holding the parameters of the model, collected in the vector $\theta' = (\tau\ \beta\ \kappa\ \psi\ \sigma_v\ \sigma_u)$.

The presence of news shocks does not alter the topological properties of the system steady state, and the determinacy region is shaped by the policy parameter ψ solely (Karnizova, 2007). When the inflation elasticity of the interest rate rule is strictly larger than one, then both the non-zero eigenvalues are outside the unit circle and the (stable) equilibrium is determinate; if $\psi < 1$, the system features instead a unique unstable root and one-dimensional indeterminacy arises. As the system is block-recursive, we consider the following equations:

7 We abstract from considering the interest rate response to changes in the targeted output.
8 Since ϕ_t is expressed as a martingale difference sequence with respect to v_t.
9 See Appendix B.

$$\begin{pmatrix} 1 & \tau & 0 \\ 0 & \beta & 0 \\ 0 & 0 & 1 \end{pmatrix}\begin{pmatrix} E_t(x_{t+1}) \\ E_t(\pi_{t+1}) \\ E_t(v_{t+1}) \end{pmatrix} = \begin{pmatrix} 1 & \tau\psi & \tau \\ -\kappa & 1 & 0 \\ 0 & 0 & 0 \end{pmatrix}\begin{pmatrix} E_{t-1}(x_t) \\ E_{t-1}(\pi_t) \\ E_{t-1}(v_t) \end{pmatrix} + \begin{pmatrix} \tau & 0 \\ 0 & 0 \\ 0 & 1 \end{pmatrix}\begin{pmatrix} \phi_t^0 \\ \phi_t^1 \end{pmatrix} + \begin{pmatrix} 1 & \tau\psi \\ -\kappa & 1 \\ 0 & 0 \end{pmatrix}\begin{pmatrix} \eta_t^x \\ \eta_t^\pi \end{pmatrix} \quad (10)$$

or:

$$\Gamma_0^*(\theta)y_t^* = \Gamma_1^*(\theta)y_{t-1}^* + \Psi^*(\theta)\phi_t + \Pi^*(\theta)\eta_t, \qquad t \geq 1 \quad (11)$$

whose stability properties are determined by the eigenvalues of $(\Gamma_0^*(\theta)^{-1}\,\Gamma_1^*(\theta))$. In fact, the following relation:

$$y_t^* = \Gamma_0^*(\theta)^{-1}\Gamma_1^*(\theta)y_{t-1}^* + \Gamma_0^*(\theta)^{-1}\Psi^*(\theta)\phi_t + \Gamma_0^*(\theta)^{-1}\Pi^*(\theta)\eta_t, \quad t \geq 1 \quad (12)$$

represents the full set of solutions of the LRE system, including unstable ones, for any arbitrary i.i.d. white noise process η_t. Existence of a non-explosive equilibrium requires that the vector of endogenous forecast errors be able to offset the effect of news-driven expectations revisions on the unstable components of the system. Once the suitable stability requirement is met (Sims, 2002), the non-explosive (possibly non-unique) equilibrium obtains for:

$$\begin{pmatrix} \eta_t^x \\ \eta_t^\pi \end{pmatrix} = \frac{\kappa\tau}{c^2}\begin{pmatrix} -\kappa\lambda_2 & \dfrac{\beta\kappa\lambda_2}{2a} \\ b & \dfrac{\beta b}{2a} \end{pmatrix}\begin{pmatrix} \phi_t^0 \\ \phi_t^1 \end{pmatrix} + \frac{1}{c}\begin{pmatrix} b \\ \kappa\lambda_2 \end{pmatrix}M_1\begin{pmatrix} \phi_t^0 \\ \phi_t^1 \end{pmatrix} + \frac{1}{c}\begin{pmatrix} b \\ \kappa\lambda_2 \end{pmatrix}M_2\zeta_t \quad (13)$$

or in a more compact notation:

$$\eta_t = -\Lambda(\theta)\phi_t + V_{\tilde{\Pi},2}(\theta)M_1\phi_t + V_{\tilde{\Pi},2}(\theta)M_2\zeta_t \quad (14)$$

where λ_2 is the only unstable root of the system and $a = 1 + \tau\kappa\psi$, $b = \lambda_2 - a$ and $c = \sqrt{(\kappa\lambda_2)^2 + b^2}$ (Lubik and Schorfheide, 2003; Karnizova, 2007). The matrix pair (M_1,M_2) which is needed to add back to the system the components of the equilibrium forecast errors left undetermined by the stability condition, is unrestricted as it does not depend on the deep parameters of the RE system (i)-(iv). Under $V_{\tilde{\Pi},2}$ indeterminacy, is non-empty and sunspot shocks can influence equilibrium dynamics whenever $M_2 \neq 0$.

Let $\{y_t^o\}$ be the measurements on (x_t, π_t, R_t) – generally expressed as deviations from annualized steady state values – which are in the information set of the econometrician, who can thus exploit a Kalman filtering-based recursive technique to evaluate the likelihood function in order to derive econometric inference on (i)-(iv). Assume $p = l(J + 1)$[10]. In this case, even normalizing M_2 to one, it is impossible to establish whether the data are generated by an indeterminate model driven by both fundamental innovations with different period of realizations (news-driven beliefs revisions) and non-fundamental sunspots, whose impact on η_t is orthogonal to the contribution of the former:

$$\eta_t = -\Lambda(\theta)\phi_t + V_{\tilde{\Pi},2}(\theta)\zeta_t, \qquad M_1 = 0 \quad (15)$$

or rather by an indeterminate model driven purely, though arbitrarily, by expectations revisions:

$$\eta_t = [-\Lambda(\theta) + V_{\tilde{\Pi},2}(\theta)M_1]\phi_t + V_{\tilde{\Pi},2}(\theta)\mu_t, \qquad M_1 = \Sigma_{\phi\zeta}\Sigma_\phi^{-1} \quad (16)$$

10 This assumption is required for the covariance between expectations revisions and sunspot shocks to be a well-defined function.

where $\Sigma_{\phi\zeta} \equiv E(\phi\zeta')$. Specifically, the covariance structure Σ_{ϕ} of exogenous expectations revisions as major driving impulse of the dynamic stochastic model is easily recovered from the process for news shocks as described in Section 2. When $\Sigma_{\phi\zeta} \neq 0, \zeta_t$ admits a linear noise corrupted representation of the form $\zeta_t = \Sigma_{\phi\zeta} \Sigma_{\phi}^{-1} \phi_t + \mu_t$, for some shock μ_t satisfying $E_{t-1}(\mu_t) = 0$. As the two expressions always generate the same reduced form forecasts, the New Keynesian monetary model subject to both news shocks and sunspots which exhibit orthogonal contributions to such errors is equivalent to an indeterminate equilibrium model of the same structure and yet arbitrarily driven by news shocks solely. In fact, equivalence results from imposing a given correlation structure between exogenous expectations revisions and sunspot shocks as well as on the reduced form impact matrix M_1, which are not pinned down by the structure of the model. Since identification of the former cannot be coupled with the identification of the covariance between fundamental shocks and sunspot variables, in empirical exercises this matrix is typically normalized to zero (e.g., Lubik and Schorfheide, 2004). In this sense, reliability of indeterminacy testing procedures is likely to rest on unknown structural features or untestable restrictions on the actual data generation process.

Example 2 – Similarly, given equilibrium equations (12)-(13), actually observed data may be consistent with a determinate model driven by news shocks solely:

$$\eta_t = -\Lambda(\theta)\phi_t, \qquad V_{\tilde{\Pi},2}(\theta) = 0 \tag{17}$$

or rather with an indeterminate one in which exogenous expectations revisions are arbitrarily related to sunspot variables[11]:

$$\begin{aligned} \eta_t &= [-\Lambda(\theta) + V_{\tilde{\Pi},2}(\theta)M_1]\phi_t + V_{\tilde{\Pi},2}(\theta)M_2\zeta_t \\ \zeta_t &= \Xi\phi_t, \qquad M_1 = -M_2\Xi \end{aligned} \tag{18}$$

If the difference between the dimension k of the rational forecast errors vector η_t and the number r of restrictions imposed on the latter by the explosive components of the model turns equal, for the specific model at hand, to the dimension p of the sunspot vector, M_2 is a square matrix; if the latter is non-singular, then we can restrict Ξ to generate observational equivalence for any choice of the otherwise undetermined pair (M_1, M_2).

Example 3 – Finally, we provide an example of a single equation model with a determinate equilibrium purely driven by news shocks and a single equation model with an indeterminate equilibrium subject to fundamental (unanticipated) shocks and non-fundamental sunspots, that are observationally equivalent.

The first framework, considered in Fève *et al.* (2009), allows the scalar endogenous variable to depend on its first lag, its own one-step ahead expected value and an anticipated shock; deep parameters are selected to ensure the existence of a unique (determinate) RE equilibrium[12]:

$$\begin{aligned} y_t &= \frac{\alpha_1}{1+\alpha_1\beta_1} y_{t-1} + \frac{\beta_1}{1+\alpha_1\beta_1} E_t(y_{t+1}) + \frac{1}{1+\alpha_1\beta_1} v_t \\ \alpha_1 &\in (-1,0) \cup (0,1), \qquad |\beta_1| < 1 \end{aligned} \tag{19}$$

11 For any non-empty $\Xi_{p\mathrm{x}(l+Jl)}$ matrix.
12 We also require that α_1 be non-zero for the model (19) to display a backward-looking dimension.
13 That is, by requiring $E(y_t) < \infty$ when $t \to \infty$, for any initial condition y_0.

with the driving variable following a stochastic process of the form:

$$v_t = \varepsilon_{t-q}, \qquad \varepsilon_t \sim i.i.d.\, D_\varepsilon(0, \sigma_\varepsilon^2) \tag{20}$$

Thus, model (19) is subject to a news shock, which is anticipated $q \geq 1$ periods ahead. Let us first assume $q = 1$ for simplicity. Under the parametric restrictions which guarantee determinacy, and imposing a boundedness condition on the sequence for $E(y_t)$[13], the model yields a unique, stationary solution that only involves fundamentals, expressed in ARMA (1,1) reduced form:

$$(1 - \alpha_1 B) y_t = \beta_1 (1 + \beta_1^{-1} B) \varepsilon_t \tag{21}$$

where B denotes the backshift operator (i.e., $B^g\, y_t = y_{t-g}$). This feature is structural insofar as the autoregressive as well as the moving average components depend only on the deep parameters (α_1, β_1) governing the intertemporal choices in y_t and the impact of the fundamental shock respectively, whereas both bubbles phenomena and sunspot-driven fluctuations have been ruled out. However, while the autoregressive representation is stationary, the MA process is non-fundamental insofar as the root of the associated characteristic polynomial lies inside the unit circle; as a result, the structural MA representation cannot be uncovered from structural VAR models on the observables (Fève *et al.*, 2009).

A more subtle identification issue is also present. To illustrate the point, let us consider the alternative single equation model:

$$y_t = \alpha_2 E_t(y_{t+1}) + \beta_2 \varepsilon_t, \qquad |\alpha_2| > 1 \tag{22}$$

forced by the i.i.d. shock ε_t. Here the RE equilibrium is indeterminate and therefore subject to non-fundamental noise:

$$y_t = \alpha_2^{-1} y_{t-1} - \alpha_2^{-1} \beta_2 \varepsilon_{t-1} + \zeta_t, \qquad E_{t-1}(\zeta_t) = 0 \tag{23}$$

where ζ_t is a martingale difference sequence (e.g., Gourieroux *et al.*, 1982; Broze and Szafarz, 1991). We can interpret the latter as a non-fundamental forecast error which is not endogenously determined as a function of the fundamental shock ε_t; for the determinate equilibrium model (19), on the contrary, there exists a one-to-one mapping from the latter to the endogenous forecast error, namely $\eta_t = \beta_1 \varepsilon_t$. Though the models (19) and (22) produce different equilibrium reduced form representations, it may still prove impossible to distinguish between them. Suppose that the determinate equilibrium one is the actual data generating process. Then, for any element in the set $S = \{(\alpha_1, \alpha_2, \beta_2) : \alpha_1 \alpha_2 = 1,\ \alpha_2 + \beta_2 = 0\}$, which is non-empty, it is always possible to find a sunspot shock with distribution D_ζ and standard deviation $\sigma_\zeta = \beta_1 \sigma_\varepsilon$ such that model (19) and model (22) are observationally equivalent. This identification failure does not stem from the ambiguity in the model responses to news shocks under indeterminacy, since the former are not assumed to influence the second economy.

More generally, let us consider a (finite) anticipation horizon $q \geq 1$, and introduce a purely forward-looking model with MA $(q - 1)$ forcing term:

$$\begin{aligned} y_t &= \alpha_2 E_t(y_{t+1}) + \beta_2 \Delta(B) \varepsilon_t, \qquad |\alpha_2| > 1 \\ \Delta(B) &= \textstyle\sum_{i=0}^{q-1} \delta_i B^i, \qquad \delta_0 = 1 \end{aligned} \tag{22'}$$

Then the following holds:

Proposition 1 – *A sunspot equilibrium model always exists, which is observationally equivalent to the news shocks model (19).*

Proof. See Appendix C.

4. Conclusion

This note discusses the identifiability of RE models under different sources of rational forecast errors. The illustrated observational equivalence issue entails the possibility of mistaking news on various fundamentals by sunspot noise and points to a potentially severe difficulty in the design of econometric procedures intended to empirically assess the relative importance of different types of shocks to expectations as drivers of macroeconomic fluctuations. Our message is that devicing valid tools to test between news and sunspots models is a difficult though extremely challenging task.

Appendix

A. The consolidated law of motion for a generic maximum anticipation horizon J is given by:

$$\begin{pmatrix} z_t \\ E_t(v_{t+1}) \\ \vdots \\ E_t(v_{t+J}) \end{pmatrix} = H \begin{pmatrix} z_{t-1} \\ E_{t-1}(v_t) \\ \vdots \\ E_{t-1}(v_{t-1+J}) \end{pmatrix} + \phi_t \tag{24}$$

$$H = \begin{pmatrix} \Phi_{l\times l} & I_{l\times l} & 0_{l\times(Jl-l)} \\ 0_{(Jl-l)\times l} & 0_{(Jl-l)\times l} & I_{(Jl-l)\times(Jl-l)} \\ 0_{l\times l} & 0_{l\times l} & 0_{l\times(Jl-l)} \end{pmatrix} \tag{25}$$

Equation (7) is obtained by combining equations (24)-(25) and the original system (1). In the following expression, E_t^v denotes the Jl x 1 vector representing period t conditional expectations on future realizations of fundamental impulses v_{t+i}, $i = 1, 2, \ldots, J$:

$$\widetilde{y}_t = \begin{pmatrix} y_t \\ z_t \\ E_t^v \end{pmatrix}; \quad \phi_t = \begin{pmatrix} \phi_t^0 \\ \phi_t^1 \\ \vdots \\ \phi_t^J \end{pmatrix}; \tag{26}$$

$$\widetilde{\Gamma}_0 = \begin{pmatrix} \Gamma_{0_{n\times n}} & -\Psi_{n\times l} \vdots 0_{n\times Jl} \\ 0_{(l+Jl)\times n} & I_{(l+Jl)\times(l+Jl)} \end{pmatrix}; \quad \widetilde{\Gamma}_1 = \begin{pmatrix} \Gamma_{1_{n\times n}} & 0_{n\times(l+Jl)} \\ 0_{(l+Jl)\times n} & H_{(l+Jl)\times(l+Jl)} \end{pmatrix} \tag{27}$$

$$\widetilde{\Psi} = \begin{pmatrix} 0_{n\times(l+Jl)} \\ I_{(l+Jl)\times(l+Jl)} \end{pmatrix}; \quad \widetilde{\Pi} = \begin{pmatrix} \Pi_{n\times k} \\ 0_{(l+Jl)\times k} \end{pmatrix} \tag{28}$$

B. To obtain the linear RE representation (9) of the prototypical New Keynesian model, the following matrices are used:

$$\Gamma_0(\theta)=\begin{pmatrix}1&0&0&0&0&0\\0&1&0&0&0&0\\0&0&1&0&0&0\\0&0&0&1&\tau&0\\0&0&0&0&\beta&0\\0&0&0&0&0&1\end{pmatrix};\qquad \Gamma_1(\theta)=\begin{pmatrix}0&0&0&1&0&0\\0&0&0&0&1&0\\0&0&0&0&0&1\\0&0&0&1&\tau\psi&\tau\\0&0&0&-\kappa&1&0\\0&0&0&0&0&0\end{pmatrix} \tag{29}$$

$$\Psi(\theta)=\begin{pmatrix}0&0\\0&0\\1&0\\\tau&0\\0&0\\0&1\end{pmatrix};\qquad \Pi(\theta)=\begin{pmatrix}1&0\\0&1\\0&0\\1&\tau\psi\\-\kappa&1\\0&0\end{pmatrix} \tag{30}$$

C. Proof of Proposition 1 System reduction for model (19) under $q \geq 1$ leads to:

$$(1-\alpha_1 B)y_t = \sum_{i=0}^{q}\beta_1^{q-i}\varepsilon_{t-i} \tag{21'}$$

with $\varepsilon_t \sim i.i.d.\, D_\varepsilon(0,\sigma_\varepsilon^2)$. The equilibrium reduced form for equation (22') is:

$$(1-\alpha_2^{-1}B)y_t = -\alpha_2^{-1}\beta_2 B\Delta(B)\varepsilon_t + \zeta_t, \qquad E_{t-1}(\zeta_t)=0 \tag{31}$$

where $\Delta(B)$ is the same MA polynomial of the forcing process in (22'). Equation (31) generates infinite solutions according to the arbitrary shock ζ_t. Given assumptions on the distribution for ε_t, observational equivalence then results for $\zeta_t \sim D_\zeta$ with $\sigma_\zeta = \beta_1^q \sigma_\varepsilon$ and letting:

$$\alpha_1\alpha_2 = 1; \qquad \beta_2 = -\alpha_1^{-1}\beta_1^{q-1}, \qquad \delta_i = \beta_1^{-i} \quad i=1,2,\cdots,q-1 \tag{32}$$

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