Taxes, Social Subsidies and the Allocation of Work Time

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Abstract

We examine the allocation of hours of work across industrial sectors in OECD countries. We find large disparities across three sector groups, one that produces goods without home substitutes,and two others that have home substitutes but treated differently by welfare policy. We attribute the disparities to the countries' tax and subsidy policies. High taxation substantially reduces hours in sectors that have close home substitutes but less so in other sectors. Subsidies increase hours in the subsidized sectors that have home substitutes. We compute these policy effects for nineteen OECD countries.

Keywords. allocation of time, social subsidies, tax wedge, multi-sector model, home production.

JEL classifications. E2, H5, J2

There are large differences in the kind of jobs that people do across the industrial countries of the Organisation for Economic Cooperation and Development (OECD). To illustrate the point, we report in Table 1 the percentage distribution of hours of work in three countries with different taxes and so-

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Table 1:
Percentage Distribution of Hours of Market Work in Three Countries
(average, 1994-2003)

Sector	United States	Japan	Sweden
1	63	62	63
2	10	6	17
3	27	31	21

The full definition of sectors is given in Table 3. Sector 1 is mainly manufacturing and business services, sector 2 is health and social work and sector 3 is mainly unskilled or semi-skilled services. Government administration and education are excluded.

cial support programs, the United States, Japan and Sweden.[1] Hours of work are sorted into three groups, according to whether or not the output of an industry has close substitutes in home production. Sector 1 comprises agriculture, manufacturing, business services and other services of a specialized nature, which are activities that have no counterpart in home production, as reported in time use surveys.[2] Sector 2 is the health and social work sector, which has home counterparts, especially in family care. Sector 3 consists of all other sectors, which produce less specialized services and which also have close substitutes in home production, such as retailing (a substitute for shopping time) and catering (a substitute for cooking time).

The share of sector 1 is very similar across the three countries, taking up about 63% of market work. In contrast, there are large differences in the shares of the other two sectors. Sweden has a relatively larger health and social work sector, whereas Japan has the largest share in sector 3, exceeding the Swedish share of this sector by ten percentage points. Why these large differences in the allocation of work time?

We argue that the key reason for these large differences is policy associated with the welfare state. Taxes and subsidies influence allocations along two dimensions. Consumers switch from taxed goods to subsidized ones and from buying services in the market to self-help at home. We compute tax

[1] Our aggregate is economy-wide hours of work excluding public administration, defense and education. A discussion of the data for all the countries, including social support programs and their differences, is contained in the main body of the paper. For more information on social programs see Gosta Esping-Andersen (1990, 1999).

[2] In L. Rachel Ngai and Christopher A, Pissarides (2008) we discuss in detail the kind of activities spent in home production and review their historical development. The sector allocations that we are adopting here are consisetent with that evidence. See also John Robinson and Geoffrey Godbey (1997) for the US and Michael Burda, Daniel S. Hamermesh and Philippe Weil (2008) for cross-country comparisons.

and subsidy rates for 19 OECD countries for each one of the three sectors in Table 1 and show that all countries subsidize health and social work, but Sweden and other Scandinavian countries subsidize them much more than other countries do. The tax differentials between social work on the one hand, and all other economic activity on the other, vary a lot across countries, and this could explain sectoral differences across countries, through the substitution from other market-produced goods into health and social care services.

We calculate how much is this substitution given reasonable elasticity estimates and find that quantitatively it is small. For example, when an accountant's services are taxed and a childminder's services subsidized, a family may hire an accountant for fewer hours and take the child to a childcare center, but the elasticity of substitution between the services of an accountant and the services of a childminder is not large enough to support the required quantitative impact. Moreover, since sectors 1 and 3 are taxed at the same rate and neither is subsidized, cross-market substitutions cannot explain why the substitution is mainly from sector 3 into health and social work, and not from both other sectors.

In order to explain the big quantitative impact of tax-subsidy programs and the asymmetric response of different sectors, we need the substitution between market and home production. When market goods and services are taxed, households turn to producing some of those goods in the home, where work is untaxed. Similarly, when market-provided social care is subsidized, less of it is done at home and there is more take-up of social services in the market. Some market-produced goods have close substitutes in home production, and so their response to the tax or subsidy is large. Other goods have less good substitutes in home production, implying lower response. The differential substitutions between market and home production, when combined with the differential tax treatment of social work, drive our results.

We are not the first ones to study the impact of taxes and subsidies and market-home substitutions on market economic activity. But we believe that we are the first ones to study the impact of different net taxes across sectors and derive the implied equilibrium allocation of market work. At the micro level, Richard B. Freeman and Ronald Schettkat (2005) study time use data for a small number of countries and conclude that there is virtually one-for-one substitution between home and market work across individuals, a claim that was partially supported by Michael Burda, Daniel S. Hamermesh and Philippe Weil (2008). Our results require substantial market-home substitutions at the micro level and they are consistent with one-for-one substitutions for some goods. Also at the micro level, although emphasizing sectoral differences, Steven J. Davis and Magnus Henrekson (2005) study questions similar

to ours in a partial equilibrium task-assignment model. They estimate the impact of taxation on employment in three sectors of economic activity, eating and drinking establishments, lodging and retail trade.[3] Their estimation results are consistent with the results of our model.

The macro literature has focused on total hours of work, a topic that we do not address. A main motivation for the macro literature is the reconciliation of high taxation with high participation in Scandinavian countries, which goes against the predictions of Edward C. Prescott's (2004) influential study. The claim made in the more recent literature, consistent with our analysis, is that it is not only taxes that matter, but also how the tax revenue is spent. Prescott effectively assumed that all tax revenue is returned to the public as a lump sum transfer. Lump sum transfers have income effects but no substitution effects, so taxes in his model have their maximum impact on hours of work. But if some of the tax revenue is returned as a consumption subsidy, the tax distortion is reduced. Richard Rogerson (2007) illustrates how the impact of taxes on hours of work in a standard model varies according to the assumptions made about the distribution of tax revenue. He argues that the Scandinavian "outlier" could potentially be explained by a larger consumption subsidy given by Scandinavian countries.

Kelly S. Ragan (2010) goes one step further and calculates the consumption subsidy for purchasing market services related to child care and elderly care. In that respect her study is similar to ours. She uses the computed subsidy to calculate its impact on the choice between total home and total market work, making use of a variant of Rosen's (1997) model. She derives a weaker effect of general taxation on total market hours in Scandinavia because of a bigger subsidy in that group of countries. We study its impact at the level of a finer sector decomposition. Because of the aggregative focus of her work, she applies the consumption subsidy to market substitutes of all home production. We disaggregate market substitutes of home production into those that are subsidized and those that are not, and compute a net tax wedge for each sector.

Total hours of work in Sweden and how they compare with the United States is also the focus of Conny Olovsson (2009), who notes that the sum of market and home hours in Sweden and the United States is about the same, but market hours in the United States account for a bigger fraction of the total. He calibrates whole-economy models for the two countries and shows that the differences in time allocations are explained by the higher taxation

[3]They deliberately omit childcare because of difficulties in constructing comparable subsidy rates across the countries in their sample, one of the challenges that we take up in this paper. Their sample of countries for the employment regressions varies between 9 and 14 countries, depending on data availability.

of market work in Sweden. Richard Rogerson (2008) is another study that emphasizes the distortionary impact of taxes because of the market-home substitution. He uses his model to derive the change in total hours of work in services between 1956 and 2003 in an aggregate of five continental European countries, and compares the outcome with the United States. He shows that the bulk of the difference can be explained by the bigger rise in taxes in Europe over this period.

Because of the important role of the disbursement of tax revenue, the authors who studied total hours of work are forced to make some strong assumptions about it. For example, like Prescott(2004), Rogerson (2008) assumes that all tax revenue is returned to consumers as a lump sum. Olovsson (2009) explores different assumptions, one of which assumes that some tax revenue is used up by the government to finance its own consumption. Moreover, in order to obtain their results, these authors also assume that the government balances incomes and revenues every period, a strong assumption for cross-country comparisons, where debt and deficit levels vary substantially. In contrast, in our study of the allocations across sectors, we do not need to make any assumptions about the use of net tax revenue (gross taxes net of social subsidies), or the government budget, to obtain our results. We consider this to be an important advantage of our work over the studies of whole-economy hours. Our sample of 19 countries is also a much bigger number than in most previous studies, despite the bigger disaggregation that we do.[4]

The key to our model are two elasticities of substitution, the one between market goods and the one between market and home production. We show that general taxation has a greater impact on sector 3, services with home substitutes, than on sector 1, whose output has no home substitutes, because sector 3 loses more hours to the untaxed home sector. But health and social care is subsidized, so market hours gain both from the home sector (if the subsidy is large enough to outweigh the impact of the income tax) and from the other two non-subsidized sectors.[5]

In order to quantify our predictions we need three different types of data.[6] First, we need to know the hours of work allocated to different sectors, which

[4]The papers on total hours disaggregate, at best, between all services and manufacturing. A pioneering discussion of the differential impact of policy on the allocation of work in Sweden is contained in Assar Lindbeck (1982). See also Assar Lindbeck (1997) for more detailed discussion of the Swedish welfare state and its role in the economy.

[5]Unfortunately, it is not possible to distinguish between high-skill health care, e.g., surgery, and social work, such as childcare centers or elderly care. Ideally, our sector 2 should exclude high-skill health care which has no home substitutes.

[6]See the Web Appendix for a full listing of data sources and definitions.

are available for a fairly large number of countries at the two-digit level through the database *Productivity in the European Union: A Comparative Industry Approach* (EU KLEMS). Second, we need the size of social expenditure on benefits in kind, such as day care centers, which can be obtained from the OECD *Social Expenditure Database* (SOCX). Finally, we need to know the hours allocated to different activities at home, which we obtain from time use surveys. We constructed comparable data sets for 19 OECD countries and we focus on cross-country differences around the time of the time use surveys, circa 2000. These countries include several European countries from Scandinavia to the Mediterranean, the United States, Canada, Australia, New Zealand, Japan and Korea, so we have a good mix of tax and subsidy regimes.

Section 1 describes our model of three market and two home sectors. We derive equilibrium allocations as functions of three sets of parameters, preferences, technology and policy. In section 2 we describe the relevant data for the 19 countries in our sample and summarize their main features. In section 3 we give the parameter values used in the quantitative evaluation of the impact of policy. The quantitative evaluation begins with section 4, where we illustrate the workings of the model within the policy parameter range calculated in the data section, and refer back to the example of Table 1. Predictions with the full sample are given in sections 5, 6 and 7, beginning with cross-market substitutions and following up with substitutions between market and home production.

1 The model

Consumer allocations. We solve the time allocations for a representative agent who has a static CES utility function defined over consumption goods produced at home and in the market, and over leisure. She is a price and wage taker in the market, conditional on taxes and transfers chosen by the government, and chooses home production conditional on linear production functions. There is no capital in the model so it can be solved as a static resource allocation problem, with linear production functions for market goods as well and market clearing throughout. There are no profits in equilibrium and all income is in the form of wages.

The representative agent's utility function is

$$U\left(c, l_m, l_h\right) = \ln c + v(1 - l_m - l_h), \tag{1}$$

where c is a consumption aggregate, l_m is market work (private and government), and l_h is home work. $v(.)$ is an increasing concave function. Aggregate

consumption is a CES aggregate of three types of goods, denoted by $\tilde{c}_i$,

$$c = \left[\sum_{i=1}^{3} \omega_i \tilde{c}_i^{(\varepsilon-1)/\varepsilon} \right]^{\varepsilon/(\varepsilon-1)}, \tag{2}$$

where $\varepsilon \geq 0$ is the constant elasticity of substitution and $\omega_i > 0$, $\Sigma\omega_i = 1$. Each $\tilde{c}_i$ is a composite of market-produced and home-produced goods in sector i. Sector 1 is comprised of all goods that have no home-produced substitutes, so $\tilde{c}_1$ is the market good c_1. In sectors 2 and 3, $\tilde{c}_i$ is a CES aggregate of market and home produced goods,

$$\tilde{c}_i = \left[\psi_i c_i^{(\sigma_i-1)/\sigma_i} + (1-\psi_i) c_{ih}^{(\sigma_i-1)/\sigma_i} \right]^{\sigma_i/(\sigma_i-1)} \qquad i = 2, 3, \tag{3}$$

where c_i is market-produced consumption, c_{ih} is consumption of goods produced at home, $\sigma_i \geq 0$ is the elasticity of substitution between home and market consumption for each good i and $\psi_i \in (0, 1)$.

Government taxes wage income at rate τ, and each market good at a net rate t_i (the gross tax rate less any subsidy). It also taxes or subsidizes employment, at a rate t_e. It uses its net revenue from the taxes and subsidies to employ labor, supply goods to consumers or consume other goods. We assume that the product of public administration is a public good that is separable from the goods included in the aggregate c. We also exclude from c education services, because they are not a final consumption good but an investment good. The employment used to produce the public good and education is part of l_m.

We do include in c health and social care. This is because our focus is on social care, which is clearly a consumption good that can be produced both at home and in the market. The amount of health services consumed by the representative agent is also a matter of consumption decisions, depending on the cost to the individual. Health and social care are subsidized by the government, either directly through the provision of subsidized care or through transfers. We treat the subsidy as a negative tax, with the individual having free choice over the quantity that she consumes at the subsidized price.

Governments also make lump-sum transfers T to the representative agent. Part of the lump sum transfer is a component of social policy, like for example transfers to families with children. But lump sum transfers also include tax revenue not used to subsidize consumption of certain goods or employ labor. We briefly return to this topic below.

The disutility from work is independent of sector or location and there is perfect labor mobility. The wage rate is the same in all sectors, so the

budget constraint on the consumption of market goods is,

$$\sum_{i=1}^{3}(1+t_i)p_i c_i \leq (1-\tau)wl_m + T. \tag{4}$$

The consumption of home goods is constrained by the linear production functions,

$$c_{jh} \leq A_{jh} l_{jh}, \quad j = 2, 3, \tag{5}$$

where l_{jh} is the time allocated at home to each activity j and A_{jh} is labor productivity in each activity.

In order to solve the problem it is convenient to define a new budget constraint for total work $l \equiv l_m + l_h$, that incorporates the production constraints (5). Define "total" after-tax income by $(1-\tau)wl$, and make use of it and (5) to re-write (4) as,

$$\sum_{i=1}^{3}(1+t_i)p_i c_i + \sum_{j=2}^{3} p_{jh} c_{jh} \leq (1-\tau)wl + T, \tag{6}$$

where $p_{jh} \equiv (1-\tau)w/A_{jh}$ is a net implicit (producer) price for home-produced goods. The numerator is the net wage that the household could get by supplying one unit of labor to the market, and the denominator is the number of units of the home good that she could get by supplying the same unit to home production.

The consumer problem is the maximization of (1)-(3) subject to the single constraint (6). From the optimality conditions we derive some key results.

Total work hours. The first-order maximization conditions yield the following result for total hours of work, l :

$$\frac{1}{v'(1-l)} - l = \frac{T}{(1-\tau)w}. \tag{7}$$

In the absence of lump-sum transfers, total work depends only on preference parameters, because of the logarithmic utility of aggregate consumption. The supply of hours to the market then varies only to the extent that there are substitutions between home and market production (which we call, following Freeman and Schettkat (2005) "marketization"). In L. Rachel Ngai and Christopher A. Pissarides (2008) we showed that such substitutions can give non-trivial labor supply dynamics, driven by the dynamics of technology. But if there are implicit or explicit lump sum transfers, both the dynamics and cross-sectional properties of the supply of labor become richer, because now there are two substitution margins, the one for overall leisure and marketization. In general, the bigger the lump sum transfer, the stronger the impact of taxation on market work.

Cross-country studies of differences in total hours make use of an equation like (7) to derive their quantitative conclusions. The usual approach, however, is not to compute T directly, but to assume that the government balances its budget with an appropriate choice of T and no borrowing. T is then substituted out of (7) from the budget constraint, leaving only taxes in it (see e.g., Prescott, 2004, Rogerson, 2008, and Ragan, 2010). This implicitly treats all tax revenue (in Ragan's case net of social subsidies) as a lump sum transfer. Government consumption that is not a close substitute to private consumption and the government's administrative wage bill, which is paid conditional on market work, is not accounted for in these studies. This omission, and the assumption that the budget is balanced across countries in the year of the study, casts doubts on this approach to the treatment of the lump sum transfer. In this paper we do not address the question of the impact of taxation on the total number of hours of work, and as we show next this gets rid of the lump sum transfer from our equations, obviating the need to make assumptions about its measurement.

Market shares. We make predictions about the allocation of market work by computing the market share of each sector, defined by $s_j = 100 l_j / \Sigma_{i=1}^{3} l_i$. Given the structure of the model, it is convenient to derive these predictions from the model's predictions of the ratios l_2/l_1 and l_3/l_1, by re-writing the shares as:

$$s_j = 100 \frac{l_j/l_1}{\Sigma_{i=1}^{3} l_i/l_1} \qquad j = 1, 2, 3 \tag{8}$$

To make these predictions we therefore need to derive expressions for just two ratios of hours of work, l_2/l_1 and l_3/l_1. We do this in three steps.

Marketization. The composite good $\tilde{c}_j$ can be acquired by buying some c_j from the market at price $(1 + t_j)p_j$, or by producing it at home as c_{jh} at a (shadow) unit cost p_{jh}. We define "marketization" as the substitution of one unit of c_j for c_{jh}. The extent of marketization is obtained by setting the marginal rate of substitution across goods c_j and c_{jh} equal to their relative prices:

$$\frac{c_j}{c_{jh}} = \left(\frac{\psi_j}{1 - \psi_j} \frac{p_{jh}}{(1 + t_j)\, p_j} \right)^{\sigma_j} \qquad j = 2, 3. \tag{9}$$

Recalling that $p_{jh} = (1 - \tau)w/A_{jh}$, it follows that consumers marketize more of good j if they have higher net wages, if the market good is cheaper or if labor productivity in home production is lower. The impact of these parameters depends on the elasticity of substitution between market and home goods. In the limit, as $\sigma_j \to 0$, the two types of goods are consumed in fixed proportions. But for $\sigma_j > 0$ there can be a lot of differences in the marketization of home production across individuals, countries or over time,

depending on the values taken by taxes and market prices.

Relative demand for market goods. We next solve for the ratio of real demand for market goods 2 and 3, which have home substitutes, to the demand for good 1. The objective is to obtain from these ratios the employment shares in each sector of market activity. Setting the marginal rate of substitution across good j and good 1 equal to their relative price, we obtain,

$$\frac{c_j}{c_1} = \left(\frac{\omega_j \psi_j}{\omega_1}\right)^{\varepsilon} \left(\frac{(1+t_j)p_j}{(1+t_1)p_1}\right)^{-\varepsilon} \left(\frac{c_j}{\tilde{c}_j}\right)^{1-\varepsilon/\sigma_j}, \tag{10}$$

We note that $c_j/\tilde{c}_j$ is the share of good j that is marketized. It follows that the relative market demand for good j is a decreasing function of its relative consumer price and, under the plausible restriction $\varepsilon \leq \sigma_j$, an increasing function of the degree of its marketization. Marketization is an important channel through which policy influences relative market shares. Higher and uniform taxes on all goods (i.e., $t_j = t_1$) do not affect relative consumption shares for given marketization, but they imply less marketization for good j and so a lower market share for this good, relative to the market share of good 1.

The sectoral allocation of time. In order to derive the market employment shares we make use of market clearing and the production functions for each market good. Let the production functions be

$$c_i \leq A_i l_i, \quad i = 1, 2, 3. \tag{11}$$

The notation parallels that for home production, with A_i standing for the (market) labor productivity of good i and l_i for the number of hours allocated to it.

The net revenue to the firm from the sale of good i is $p_i A_i l_i$, and is used to pay for wages and employment taxes net of subsidies. Free mobility of labor implies that wages are the same in all market sectors, so if employment taxes are also the same across sectors, relative producer prices are given by the ratio of the technology parameters:

$$(1+t_e) w l_i = p_i A_i l_i \Longrightarrow \frac{p_i}{p_j} = \frac{A_j}{A_i}, \qquad i, j = 1, 2, 3. \tag{12}$$

The relative price of the market good to the implicit price of the home good is also obtained from (12), by substituting w from it into the condition $p_{jh} = (1-\tau)w/A_{jh}$. This substitution yields,

$$\frac{(1+t_j)p_j}{p_{jh}} = \frac{(1+t_j)(1+t_e)A_{jh}}{(1-\tau)A_j}. \tag{13}$$

We define the "tax wedge" that applies to sector j, denoted t_{wj}, by[7]

$$t_{wj} = 1 - \frac{1-\tau}{(1+t_j)(1+t_e)}. \tag{14}$$

With the linear production functions and the relative prices just obtained, the marketization condition (9) translates into the following condition for the marketization of time in sector j :

$$\frac{l_j}{l_{jh}} = \left(\frac{1}{\psi_j} - 1\right)^{-\sigma_j} \left(\frac{A_j}{A_{jh}}\right)^{\sigma_j - 1} (1 - t_{wj})^{\sigma_j} \quad j = 2, 3. \tag{15}$$

The marketization of time is driven by three sets of parameters, preferences, productivity, and taxes. For $\sigma_j > 1$, more is marketized when market productivity is higher than home productivity.[8] More importantly for our present objectives, the impact of policy is summarized in a single composite, the tax wedge. Higher tax wedge leads to less marketization and the impact is bigger when the elasticity σ_j is bigger.

Turning now to market sectors, we derive the employment ratios of sectors from (10) and the linear production functions:

$$\frac{l_j}{l_1} = \left(\frac{\omega_j \psi_j}{\omega_1}\right)^{\varepsilon} \left(\frac{A_1}{A_j}\right)^{1-\varepsilon} \left(\frac{1+t_j}{1+t_1}\right)^{-\varepsilon} \left(\frac{c_j}{\tilde{c}_j}\right)^{1-\varepsilon/\sigma_j}. \tag{16}$$

Calculating $c_j/\tilde{c}_j$ from (3), (9) and (13), we obtain,

$$\frac{c_j}{\tilde{c}_j} = \psi_j^{-\sigma_j/(\sigma_j - 1)} \left[1 + \left(\frac{1}{\psi_j} - 1\right)^{\sigma_j} \left(\frac{A_{jh}}{A_j(1 - t_{wj})}\right)^{\sigma_j - 1}\right]^{-\sigma_j/(\sigma_j - 1)}. \tag{17}$$

(16) is a key equation for the model because it gives the dependence of the allocation of time on policy.

Policy influences employment shares in two ways. First, for given marketization of consumption, policy influences market shares because of non-uniform taxation associated with social subsidies. If $t_j < t_1$, as would be the case if sector j is subsidized and sector 1 is not, the relative employment of

[7] For small tax rates this is approximately equal to the tax wedge used in econometric studies, $t_{wj} = \tau + t_j + t_e$, but taxes in our sample of countries are not small and the approximation is not good.

[8] To see the intuition, suppose the goods are perfect substitutes, then $\sigma_j \to \infty$ and all production moves to the more productive location. If $\sigma_j = 0$ the same quantity of each good needs to be produced and consumed, and so more labor is employed in the less productive location to compensate for the higher productivity in the other location.

sector j for given marketization is higher, because of a switch of demand from the taxed sector to the subsidized one. The extent of this switch depends on the elasticity of substitution across market goods, ε.

Second, policy influences the relative size of sectors because of the substitutions between home and market production. In a general equilibrium there is a switch of hours of work from the taxed market sector to the untaxed home sector that produces close substitutes. This distortion works even if two sectors are equally taxed ($t_j = t_1$), because sectors with closer home substitutes suffer bigger losses of demand and employment than sectors with less good home substitutes. From (16) it is clear that the condition for this intuition to go through is $\varepsilon/\sigma_j < 1$, that is, that the elasticity of substitution between home and market goods should be bigger than the elasticity of substitution across market goods.

The model makes strong predictions about two features of sectoral allocations that can be confronted with data. First, the relative employment shares in (16) depend on expenditure tax differentials and on market-home substitutions. Second, the marketization in (15) depends on the tax wedge applying to the sector. We now discuss the data needed to quantify these two predictions.

2 Data derivation and description

Time use surveys have proliferated recently but with very minor exceptions they are still mainly one-off surveys that follow similar principles across countries and over time. The United States began an annual survey in 2003 and the European Union is in the process of setting up Europe-wide standards for regular surveys across the European Union. However, for the purposes of this study we are restricted to a small number of surveys; we selected one survey for as many countries of the OECD as we could find, undertaken as close to the turn of the millennium as possible. For most countries this was the only available information. We used time use surveys to extract time spent in home production in sectors 2 and 3 of the model, as detailed below.

Time use surveys, however, despite very detailed reporting of the kind of activities done away from the market, do not report the industrial breakdown of market hours. The source of the industrial breakdown of hours of work that is comparable across countries is the EU KLEMS database, which is employer-based. We use this survey to get the percentage distribution of total market hours across the model's three sectors and the absolute number of hours in sectors 2 and 3. The absolute number of hours in each sector is needed only in the marketization equations of these two sectors.

Table 2:
The three sectors of market work

production and business services		health	other services
agriculture and allied	wholesale trade	health and social work	sale, motor repairs retail trade
mining and quarrying	air transport, post and telecom		hotels and restaurants
manufacturing	finance, insurance, real estate and business services		inland transport water transport aux. transport
gas, electricity, water	membership organizations, media activities		refuse disposal recreational, other personal
construction			

All economic sectors in EU KLEMS are included except for public administration, defence and compulsory social security (L) and education (M). The very small sector private households with employed persons (P) is also excluded from the analysis because of apparent inconsistencies in the data.

We grouped the EU KLEMS two-digit sectors into the model's three sectors according to the classifications in Table 2. The market activities in the sub-sectors included in sector 3 broadly correspond to the home-production activities reported in time use surveys, e.g., hours of work in the retail sector correspond to time spent shopping in time use surveys, restaurants match time spent cooking, etc.

For sector 2, all time use surveys report hours of childcare, which is a close substitute for market-based childcare, and most also report a smaller number of hours for care of other dependents. We were able to construct for all countries an estimate of total care done at home, including child and adult care. The equivalent market sector is health and social work,which includes the number of hours worked in child care centres, adult homes and public and private hospitals. Given that time use surveys do not report time allocated to medical care in the home, ideally we would have wanted to split the market sector into two, one for health services such as hospital treatment, which has no home substitutes, and one for caring services, with home substitutes. However, this is not possible with the available data sets, so we treat the aggregate of health and social work as the market activity, with childcare and adult household care as its close home substitute. The overall figure for adult care is small, amounting on average to 16% of total care, so our home production time for care is dominated by childcare time.

Government employment and education are excluded from the analysis.[9]

[9]One could argue that medical treatment should be excluded too, as it has many

Our aggregate economy is made up of the sectors listed in Table 2 and we study the determinants of the distribution of work among the three sectors of this economy.

The average shares of each of our three sectors for the last ten years of the sample are shown in Figure 1. The acronyms are the first two letters of the country name throughout this paper. Sector 1 is the biggest sector in all countries, but the most interesting fact that emerges from this figure is that despite its size, the cross-sectional variation in the share of sector 1 is less than that in the other two sectors. We show below that this is a key prediction of our model.

The largest shares of sector 2 hours are in the four Scandinavian countries, and the smallest in the two Mediterranean and two Asian countries covered by the sample. Although naturally no country is exactly the same as another in its treatment of welfare, there are country clusters with broadly similar policies that correspond to the rankings in Figure 1 (see Esping-Andersen 1990, 1999).[10] The Scandinavian countries have the highest levels of overall taxation but they use a large part of the revenue to subsidize market-based social services. They have the largest sector 2 share. Next come the continental European countries, which also have high taxation and subsidize heavily social services but not to the extent of the Scandinavian countries. Anglo-Saxon countries have generally lower taxation and welfare transfers, so they have relatively larger sectors 1 and 3, and correspondingly smaller sector 2 share. Finally, southern European countries do not give support to market-based social care and have the smallest relative size for sector 2. Japan and Korea are in line with southern European countries with no subsidy to market-based social care.

Policy is characterized by three types of instruments, taxes, health and social care subsidies, and lump-sum transfers. Lump-sum transfers are not relevant for our analysis but the other two instruments are. The tax rates on labor income, consumer spending and employment can be calculated from national accounts data given in OECD publications (see the Web Appendix). For each country we also calculated the employment subsidy rate as the ratio of total spending on "active employment measures" to the wage bill. The combination of these taxes net of the employment subsidy gives the tax wedge for sectors 1 and 3.

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common features with education (government support, investment in human capital, etc.). But this is not possible with the data at our disposal.

[10] The distribution of employment is close to the distribution of hours of work and results would not differ if we worked with employment shares. The correlation coefficients between the hours share and the employment share for sectors 1, 2 and 3, are, respectively, 0.88, 0.98 and 0.88.

For the health and social work sector, different countries follow different subsidization policies, and detailed case by case modeling for each country is not feasible. We follow a common approach to defining the subsidy rate, which captures the extent of subsidization of this sector. We calculated two alternative subsidy rates, one applying to social care only and one including health subsidies.

The main substitution between market and home is in social care. Our first subsidy measure includes the value of "benefits in kind" in social care, reported in SOCX, which is mainly the money governments spent on subsidizing day care centres for pre-school children and homes for older people. The second subsidy adds to this health spending on benefits in kind. Health spending is on average much larger than social care spending but it encompasses both medical services and drugs and medical equipment, which are not part of the output of the health sector. Health expenditure data for the United States shows that about half the health spending is on drugs and equipment and the other half on medical services.[11] We applied this fraction to all countries and so divided by 2 the total health subsidy reported in SOCX. Adding the result to social care spending yields our second health and social care subsidy.

The subsidy rate on health and social care is defined as the ratio of each subsidy amount calculated as in the preceding paragraph, to the gross output of the health and social work sector. As the value-added of private health and social care services is not taxed, the subsidy rate calculated for each country is the net expenditure tax on the model's sector 2, which is a negative number in all countries. The simple correlation coefficient between the two calculated subsidy rates is 0.87, so countries that heavily subsidize social care also subsidize health more generously, and conversely. Our results are very similar for the two rates and for space reasons the detailed results that we report are for the narrower definition only, mentioning only briefly some results for the broader measure. We prefer the narrower definition because the main market-home substitution is in social care and this rate includes only items that are directly measured.

Figure 2 shows the calculated tax wedge for health and social work, based on the narrower subsidy that excludes health, and the tax wedge for the rest of the economy. Countries are sorted according to the differential between the two rates. As expected, the Scandinavian countries have the biggest

[11] The *Consumption Expenditure Survey* (CEX) of the United States for 2003 gives the following expenditure breakdowns for health care: 3.1% on health insurance, 1.4% on medical services, 1.1% on drugs and 0.3% on medical supplies. Excluding insurance, the spending on medical services is 50% of total health spending. Insurance spending can be assumed to be in the same proportions as private spending.

differential between the two tax rates and the south European and North American countries the smallest. A striking feature of the data shown in Figure 2 is the cross-country variation in the two rates. There is much more variation in social subsidies than in total taxes: the total tax wedge ranges from nearly 50% in Sweden to 27% in Korea, in contrast to the tax wedge for health and social work, which ranges from -40% in Norway to $+26\%$ in Italy.[12] The correlation coefficient between the two tax wedges is equal to -0.41, picking up the obvious fact that tax rates are higher in the countries that give more social care subsidies.[13]

3 Parameter values

The key equations used in the predictions of the market shares are (15), (16) and (17). Equation (16) shows that the impact of the parameters on the ratio of hours can be divided into the impact of the substitution across the three market goods and the impact of the substitution between market and home production. However, because the expenditure taxes in sectors 1 and 3 are the same, the relative size of sector 3 to sector 1 is unaffected by the cross-market substitution.

We study the impact of policy on market shares by investigating each substitution channel separately - across market goods due to the ε elasticity, for given home production time, and between market and home due to the σ_j elasticity. The elasticity values that we used in the computations were chosen as follows.

Beginning with σ_j, we have estimates in the literature of the elasticity of substitution between all of home production and all market goods. These estimates are in the range $1.5-2.3$.[14] In our model σ_j is the elasticity of substitution between market and home goods in two sub-sectors of the economy, where there might be different substitution possibilities. Sector 3, however, includes virtually all the services that drive the aggregate elasticity of sub-

[12] In all countries, the health and social care wedge is made up of a negative expenditure tax (the social care subsidy) and two positive taxes, the income tax and the employment tax. Depending on their relative size, the outcome could be either positive or negative.

[13] Recently, Lee Ohanian, Andrea Raffo and Richard Rogerson (2008) used a different method from ours to construct a whole-economy tax wedge for a sub-sample of the OECD countries in our sample. The correlation coefficient between our tax wedge for sectors 1 and 3 and theirs is 0.88. The only apparent difference in the rank comparisons is that their method makes Spain and Australia lower tax countries than our methods do.

[14] See Peter Rupert, Richard Rogerson and Randall Wright (1995), Ellen McGrattan, Richard Rogerson and Randall Wright (1997) and Yongsung Chang and Frank Schorfheide (2003).

stitution (except for family care). With this selection of services we would expect the substitution possibilities between sector 3 and home production to be stronger than for the economy as a whole. In view of this, a value in the upper range of the aggregate estimates is more appropriate. We choose $\sigma_3 = 2.3$ as our benchmark, although even higher values might be appropriate.[15] For the health and social work sector, the substitution elasticity is likely to depend on the breakdown of the sector between the health and social work components, and on family views about the closeness of market-provided childcare to family-provided care. We have no information from direct estimates for either and we used the same value as for sector 3 in our benchmark, $\sigma_2 = 2.3$. We check the robustness of our computation results by working out the solutions for a large range of σ, from 1.5 to 10. Results are reported mainly in the web appendix, but they generally do not differ much from the benchmark ones.

The elasticity ε is the price elasticity of the three consumption aggregates in our model. In estimates based on models without home production, this is also the price elasticity of demand. But with home production the estimated price elasticity is a weighted average of the σ and ε elasticities, with weights that depend on all the parameters of the model. On the assumption that $\sigma > \varepsilon$, in a model with home production the ε elasticity should be less than the estimated overall price elasticity of demand.

Estimates of the price elasticity of demand for service goods or sub-groups within services are all below 1, and usually in the range $0 - 0.3$.[16] More recently, Berthold Herrendorf, Richard Rogerson and Akos Valentinyi (2009), addressing this issue with consumption expenditure data for the United States for 1947-2007, show that the expenditure estimate of the elasticity of substitution across agriculture, manufacturing and service goods is around 0.8. But since our production functions are for value added, a more appropriate elasticity is the one derived for the value-added components for each sector. For this estimate they derive an elasticity close to 0.

Given that the ε of our model should be less than the estimated demand elasticities in econometric studies because of the home production component, and it should be closer to the value-added estimate of Herrendorf, Rogerson and Valentinyi (2009), the upper value estimate of 0.3 of the econometric studies is an upper bound for this elasticity, with 0 a lower bound.

[15] Richard Rogerson (2008) aggregates all services together and uses a "conservative" elasticity 1.8. His service aggregate includes specialized services for which there is no home substitute, so it should be less than ours.

[16] See Rodney Falvey and Norman Gemmell (1996), Robert Summers (1985) and Richard Blundell, Panos Pashardes and Gugielmo Weber (1993) for micro-econometric estimates.

Table 3:
Alternative tax regimes

Tax	sample means	lo uniform	hi uniform	lo subsidy	hi subsidy
t_1, t_3	0.21	0.13	0.22	0.13	0.22
t_2	-0.18	0.13	0.22	-0.10	-0.48
t_{w1}, t_{w3}	0.38	0.28	0.49	0.28	0.49
t_{w2}	0.07	0.28	0.49	0.10	-0.22

Lo uniform applies a uniform tax to all sectors, with the level set at the sector 1 and 3 value for Japan. Hi uniform does the same but sets the tax rates at the levels for Sweden. The lo subsidy column gives the actual rates for Japan and the hi subsidy column gives the actual rates for Sweden.

4 A quantitative example

We begin our quantitative applications by illustrating the interaction between the cross-market and market-home substitutions that drive our results, with reference to the example discussed in the introduction and summarized in Table 1. The purpose of the example is to derive the impact on the distribution of work of uniform taxation, social care subsidies and different values of the elasticities of substitution. We assume that all countries in the sample have the same parameter values, except for their tax and subsidy rates. In light of this, the only parameters needed to get predictions, except for the policy parameters, are the two elasticities, σ and ε.

There are four tax rates that have an impact on allocations, the expenditure taxes t_1 and t_2, and the tax wedges t_{w1} and t_{w2}. Sector 3 has the same tax rates as sector 1. Table 3 shows the sample means for these tax rates and the values that are used in the illustration. The latter set are drawn from the rates calculated for Sweden and Japan, the extreme countries shown in Table 1. The column headed "lo uniform" assumes that the country is a low tax country (like Japan) but does not subsidize health and social care at all. The column headed "hi uniform" also assumes that there are no social subsidies but taxes are as high as in Sweden. The other two columns make the same assumptions about taxes but introduce the subsidies observed in Japan and Sweden.

Solving the model for the sample means and for $\varepsilon = 0.3$ and $\sigma_2 = \sigma_3 = 2.3$, we obtain the sector shares shown in the second column of Table 4. When taxation is uniform across the three sectors, and is increased from the low Japanese rates to the high Swedish rates, the distribution of work shifts from the sectors with home substitutes, 2 and 3, to the sector without

substitutes, 1. The home-market substitution is the only driving force behind the changes in the market shares in this case. Sectors 2 and 3 lose hours in similar proportions, but because sector 3 is the bigger one, most of the fall in the percentage share is in this sector. So if, for example, Sweden had the same taxes as at present, but did not use part of the revenue to subsidize health and social care, its health and social work sector would have occupied only 4.2% of total market hours, with the bulk of care taking place in the home.

When the subsidies for sector 2 are introduced, in the last two columns of Table 4, both other shares fall, approximately by the same proportion, and the share of sector 2 increases dramatically. The model predictions for Sweden are very close to the data shown in Table 1. Sector 1 gains from the high tax at the expense of sectors 2 and 3, which have home substitutes, and then sector 2 gains from the subsidy at the expense of sectors 1 and 3. Sector 1 share is almost unaffected by the policy, because the two substitution channels offset each other. But sector 3 share falls dramatically because both substitution channels act in the same direction. Japan has low taxation so it has a higher sector 3 share than Sweden, but not as high as it would have had with no taxes at all. The model's predictions for Japan are again very close to the data shown in Table 1.

It is clear from the discussion and from the computations shown in Table 4, that the home-market substitution is crucial in explaining the large variations observed in the share of sector 3 across the countries in the sample. If we assume that the elasticity of substitution between market goods and home goods is zero, we get for Sweden, respective shares of the three sectors of $62.2, 10.4$ and 27.4. Compared with the results in the hi-subsidy case in Table 4, we find that the share of sector 1 is less by 2 percentage points, but the share of sector 2 is less by 5 points and that of sector 3 is higher by 7 points. The value of ε, the elasticity of substitution across goods, required to bring the prediction of health and social work up to the 15.5% level of Table 4 is 2.1, but at that level (and $\sigma_j = 0$ for both $j = 2, 3$) the share of sector 1 is 55 and the share of sector 3 is 30.5, which are far off the data points.

We argued that the estimates of the elasticity of substitution between market and home production in the literature give a lower bound on σ_3 but we have less information about the value of σ_2, which concerns a single service. The results are, however, robust to reasonable variations of this parameter. Holding $\sigma_3 = 2.3$ and reducing the value of σ_2 from 2.3 to 0 reduces the share of sector 2 from 15.5% to 11.3%, with a corresponding increase in the share of sector 1 and virtually no change in the share of sector 3. But even at σ_2 close to 1, the share of sector 2 is 13%, that of sector 1, 66%, and that of sector 3, 21%. So the model is robust to reasonable variations in the

Table 4:
Predicted sector shares under alternative tax regimes

Sector	sample means	lo uniform	hi uniform	lo subsidy	hi subsidy
1	63.4	61.8	72.8	60.1	64.2
2	9.7	5.9	4.2	8.4	15.5
3	26.9	32.3	23.0	31.5	20.3

elasticity of substitution between home and market care.

The main contribution of this example was to show that in order to reconcile the small country differences in the share of sector 1, with the large differences in the shares of the other two sectors, the model requires a low ε elasticity and a high σ_j elasticity, especially for sector 3. Both these are consistent with the empirical estimates of these elasticities.

5 Explaining country differences: Substitutions across market goods

We show in this section that when the home production substitution is shut down, e.g., by evaluating the model solutions at $\psi_j = 1$, the taxes and subsidies that we have computed push country hours distributions in the "right" direction, but they are not large enough to explain the large differences in actual distributions, given the small ε. Moreover, if we allow ε to take larger values, the explanatory power of this channel improves, but it fails to predict the unbalanced responses of the three sectors to the tax differentials.

For $\psi_j = 1$ equations (16) and (17) yield,

$$\frac{l_j}{l_1} = \left(\frac{\omega_j}{\omega_1}\right)^{\varepsilon} \left(\frac{A_j}{A_1}\right)^{-(1-\varepsilon)} \left(\frac{1+t_j}{1+t_1}\right)^{-\varepsilon}. \tag{18}$$

For sector 2, $t_2 < t_1$ in all countries in the sample, but for sector 3, $t_3 = t_1$. Taxes therefore cannot predict differences in the ratio l_3/l_1 without the market-home substitution, but they could predict differences in the ratio l_2/l_1. These differences imply differences in market shares, which we compare with the data that we described in section 2. In deviations from log means we obtain, for each country in the sample,

$$\ln\frac{l_{2i}}{l_{1i}} - E_j \ln\frac{l_{2j}}{l_{1j}} = -\varepsilon\left(\ln\frac{1+t_{2i}}{1+t_{1i}} - E_j \ln\frac{1+t_{2j}}{1+t_{1j}}\right) \tag{19}$$

where i and j are country identifiers and E in front of the log denotes the sample mean. We use (19) to obtain a prediction for the ratio l_2/l_1 for each country.

The predictions for $\varepsilon = 0.3$, which we consider to be at the upper end of the most reasonable values at this level of aggregation, have a good correlation with the data but do not have enough variation. The simple correlation coefficient between the prediction obtained from (19) and the data for the 19 countries is 0.86. The standard deviation of the data, however, is seven times as big as the standard deviation of the prediction. The conclusion that can be reached from this is that the impact of taxes and subsidies on the relative size of sector 2 is significant and in the right direction. But the quantitative impact of the calculated tax rates when only market substitutions are considered is too small to explain the data.

We show in Figure 3a the predictions for market shares obtained from (19). Applying the methodology of (19) to sector 3 as well gives as a prediction the sample means, because there are no tax differences between sectors 1 and 3. Using the two predictions in (8) we obtain a prediction for the share of market hours in sector 2, shown in Figure 3a. The lines drawn in this figure are the 45^0 line and lines for the sample means of the data and prediction, which are the same by construction. An "ideal" prediction would have all the points lying along the 45^0 line, whereas if taxes had no explanatory power, all points would be on the sample mean line. There is clearly predictive power to the model, but the predictions are a long way from the ideal ones. The mean absolute distance of the predictions from the 45^0 line is 2.68, compared with the distance of the means of 3.02.

The predictions in Figure 3a were derived with the tax rate obtained when only social work subsidies are taken into account. The predictions with the broader measure of subsidies that includes also half of health spending by the government are very similar and not reported. The correlation coefficient between the prediction for l_2/l_1 with the data is 0.81, but the standard deviation of the data is 5.2 times as large as the standard deviation of the prediction.

The substitution margin that drives the results in Figure 3a is across market sectors only. It predicts that as health and social care are subsidized, and the other sectors taxed, consumers switch their consumption from the other market goods to health and social care. Our finding is that such a switch takes place, but because health and social care are not sufficiently close substitutes to other market goods there cannot be large substitutions, even when there are large subsidies to health and social care. It is natural to conclude from this that had there been more substitution possibilities the model would have performed better. A log-linear regression estimate of

(19) gives $\varepsilon = 1.7$ for the whole sample and $\varepsilon = 1.4$ when Korea (which is an outlier) is excluded from the estimation, with a large increase in R^2. The best fitting line to the share data is between these two, at about 1.5. Figure 3b shows the predicted series for the share of sector 2 for $\varepsilon = 1.5$. A regression line through the points virtually coincides with the 45^0 line, and gives a good fit ($R^2 = 0.72$), which shows that the best-fitting specification explains a large part of the variation in the employment share of health and social work. The absolute mean deviation of these predictions from the 45^0 line (including Korea) is 1.76, only 58% of the distance of the data points from the sample mean. However, the caveat remains that the value of the elasticity required to give this fit is far off the range of plausible values.

One might still ask if a simpler model that ignores home production, combined with a high value for ε, is a useful shortcut that might explain the data. The answer is that at least for the allocation of work time across sectors, it is not. If the simpler model were used as an approximation, the response of the other two sectors to the health and social work subsidies should be similar, and this goes against the evidence shown in Figure 1. There is more variation in the share of sector 3, and its share is better correlated with the share of sector 2, than is the share of sector 1. The implied share of sector 3 for $\varepsilon = 1.5$ improves the prediction of the sector 3 share over the mean, but only marginally. The absolute deviation of the data from the sample mean for sector 3 is 2.84, for $\varepsilon = 0.3$ it is 2.79 and for the best fitting $\varepsilon = 1.5$ it is 2.43. So although a high ε is a useful shortcut as an explanation of the differences in the share of sector 2 in terms of taxes and subsidies, it implies too large a response of sector 1 hours and too small a response of sector 3 hours.

6 Substitutions between market and home production

When we allow for the substitution between market and home goods, our model can explain with conventional parameters both the bigger impact of policy on the hours distribution across countries and the asymmetric response of sectors 1 and 3. We investigate first the impact of home production on the hours distribution conditional on observed home production. By doing this we are allowing for the differences in home production that are not due to policy to also influence the cross-market distributions. Following this we investigate the impact of policy on home production differences across countries.

Formally, in this section we are fixing the marketization of time l_j/l_{jh} for sectors 2 and 3 at the observed values in all countries, and derive the optimal allocations across the three market sectors, conditional on the observed marketizations. By fixing the marketization of time, we are effectively also fixing the marketization of consumption, so the question that we are investigating in this section is whether equation (16) does a good job predicting the employment shares, given the observed values for the tax ratios and the marketization ratios. The only difficulty with this prediction is that the marketization of consumption is not observed, so we need to replace it with a term that has the observed marketization of time in its place.

Making use of the production functions for market and home goods to obtain an expression for $c_j/\tilde{c}_j$ in terms of the marketization of time, and substituting into (16), yields

$$\begin{aligned} \ln\frac{l_j}{l_1} &= \varepsilon\ln\frac{\omega_j}{\omega_1}+\frac{\sigma_j(1-\varepsilon)}{\sigma_j-1}\ln\psi_j-(1-\varepsilon)\ln\frac{A_1}{A_j} \\ &\quad -\varepsilon\ln\left(\frac{1+t_j}{1+t_1}\right)-\frac{\sigma_j-\varepsilon}{\sigma_j-1}\ln\left(1+x_j\left(\frac{l_j}{l_{jh}}\right)^{-(\sigma_j-1)/\sigma_j}\right) \end{aligned} \tag{20}$$

where $x_j \equiv (1/\psi_j - 1)\left(A_j/A_{jh}\right)^{-(\sigma_j-1)/\sigma_j}$ is a function of preference and productivity parameters. Taking a log-linear approximation to the last term of (20) about the sample mean, we obtain,

$$\begin{aligned} &\ln\left(1+x_j\left(\frac{l_j}{l_{jh}}\right)^{-(\sigma_j-1)/\sigma_j}\right) \\ &= \ln\left(1+x_je^{\bar{z}_j}\right)+\frac{x_je^{\bar{z}_j}}{1+x_je^{\bar{z}_j}}\frac{\sigma_j-1}{\sigma_j}\left(\ln\left(\frac{l_j}{l_{jh}}\right)-E\ln\left(\frac{l_j}{l_{jh}}\right)\right) \end{aligned} \tag{21}$$

where $\bar{z}_j$ is the sample mean of $z_j = -\left(\left(\sigma_j-1\right)/\sigma_j\right)\ln\left(l_j/l_{jh}\right)$.

As before, we use the model to make predictions of the allocations across countries in deviations from sample means. Combining (20) and (21), we obtain

$$\begin{aligned} \ln\frac{l_{ji}}{l_{1i}}-E_k\ln\frac{l_{jk}}{l_{1k}} &= -\varepsilon\left(\ln\frac{1+t_{ji}}{1+t_{1i}}-E_k\ln\frac{1+t_{jk}}{1+t_{1k}}\right) \\ &\quad +\frac{x_je^{\bar{z}_j}}{1+x_je^{\bar{z}_j}}\frac{\sigma_j-\varepsilon}{\sigma_j}\left(\ln\left(\frac{l_{ji}}{l_{jhi}}\right)-E_k\ln\left(\frac{l_{jk}}{l_{jhk}}\right)\right) \end{aligned} \tag{22}$$

where i and k are country identifiers and j is the sector identifier, taking the values 2 or 3.

For sector 2, each country's deviation from the sample mean is the sum of two terms. The expenditure tax terms that were computed before from (19), and a second term that is due to home production. For sector 3 the only term in the prediction is the home production term in (22), as there are no tax distortions between sectors 1 and 3 and $t_3 = t_1$.

The coefficient $x_j e^{\bar{z}_j}/(1+x_j e^{\bar{z}_j})$ is a number between 0 and 1 but we have no information about it, being a combination of preference and technology parameters over market and home consumption. If this coefficient were 0, home production would play no role in the allocation of market work, so it is obviously important for our results. However, it turns out that the results are robust to a large range of values for this coefficient, once it exceeds a low value such as 0.2. We adopted the following approach to finding a value for it. $\bar{z}_j$ can be calculated directly from the data on home and market production. To get a value for x_j we assume that the productivity ratio A_j/A_{jh} is 1 in both sectors, as these are low-skill services, and that the preference ratio $(1-\psi_j)/\psi_j$ is equal to the average ratio of home to market production. These targets hold exactly for $\sigma_j = 1$, but we do not impose this restriction on σ_j in any of the other calculations. The outcome for each sector is,[17]

$$\frac{x_2 e^{\bar{z}_2}}{1+x_2 e^{\bar{z}_2}} \frac{\sigma_2 - \varepsilon}{\sigma_2} = 0.64 \tag{23}$$

$$\frac{x_3 e^{\bar{z}_3}}{1+x_3 e^{\bar{z}_3}} \frac{\sigma_3 - \varepsilon}{\sigma_3} = 0.80. \tag{24}$$

The predictions for the ratios l_2/l_1 and l_3/l_1, when the values in (23) and (24) are used, are now much closer to the data than they were without the home production terms. For sector 2, the standard deviation of the data series is only 1.33 times the standard deviation of the predicted series, and the correlation between the two series is 0.89. Moreover, these predictions are virtually identical to the ones for a lower σ_2. For $\sigma_2 = 1.5$, the ratio between the standard deviation of the data to the prediction is 1.49, and the correlation between the two series remains at 0.89. For sector 3 the standard deviation of the data is only 0.44 times the standard deviation of the prediction, with correlation 0.55, but this is largely due to Korea, which is an outlier. If Korea is omitted from the sample, the ratio of the standard deviations becomes 0.62 and their correlation coefficient is also 0.62.

We now use these predictions, including Korea, to derive predictions for the sector market shares. These are shown in Figures 4a and 4b for $\sigma_2 =$

[17] A log linear regression estimate of (22) over the cross section of 19 countries gives the following estimates for this coefficient: 0.67 for sector 2, with p value 0.0003, and 0.34 for sector 3, with p value 0.0007. The regression for sector 2 also gives an estimate for ε, but still one that we would regard to be too high, 0.77, with p value 0.03.

$\sigma_3 = 2.3$.[18] The model fits the data well for both sectors, except for the Korea outlier in sector 3. As before, the three lines are the 45^0 line and the lines for the sample means. The model picks up well the Scandinavian group of countries in both sectors, as well as the smaller deviations across the other countries. The large majority of countries, and all the ones with large deviations from the sample mean, are pushed towards the 45^0 line by the model. The average absolute difference between the data and the prediction for sector 2 is 1.45, compared with the deviation between data and sample mean of 3.02. In sector 3, the model is also pushing the vast majority of countries towards the 45^0 line but the averages are distorted because of the Korea outlier. The average absolute deviation between data and prediction is 3.14, compared with the average distance between data and sample mean of 2.84. But when Korea is omitted, the model's average distance from the data goes down to 2.64.[19]

7 Can taxes and subsidies explain marketization?

We conclude that a combination of symmetric cross-market substitutions with asymmetric market-home substitutions explains the observed differences in the distribution of hours of work. But can taxes explain the cross-country differences in the marketization of time? The key marketization equation of the model is (15), which makes the marketization of time a log-linear function of preference parameters, productivity parameters and the tax wedge. As in previous sections, we assume that preferences and productivities are common across the countries of the sample and investigate the extent to which differences in the tax wedge can explain the observed differences in the marketization of time. Figures 5a and 5b show the results with the elasticities of substitution previously used, 2.3 in both sectors.[20] The model picks up well

[18] The web appendix reports predictions for lower values of σ. They are virtually indistinguishable from the ones shown in Figure 4.

[19] The problem with Korea is that it has extremely high marketization ratio in sector 3. The model then predicts extremely high market share for this sector, but in the data it is not as high because market hours are also very high for sector 1. None of the papers that attempt to predict differences in market hours across countries with taxes include Korea in their sample. The extremely high number of aggregate market hours in that country would defy any prediction based on policy.

[20] Simple log-linear regressions of equation (15) with the 19 observations for sectors 2 and 3 give respectively $\sigma_2 = 1.3$ ($p = 0.057$) and $\sigma_3 = 2.2$ ($p = 0.0005$). This ranking is consistent with our discussion in section 3. Moreover, as we have already argued, the predictions of the share of sector 2 with an elasticity like the estimated one are virtually

the difference between the Scandinavian countries and the rest of the sample in the marketization of family care, but there are clearly other influences on the marketization of care.[21] The correlation between data and prediction with $\sigma_2 = 2.3$ is 0.645. Results are virtually identical for a lower elasticity of substitution. For $\sigma_2 = 1.5$, the correlation improves slightly to 0.654 but the graph of the predictions against the data is indistinguishable from Figure 5a. Similarly, when the broader subsidy that includes health is included, the results are also very similar to the ones shown in Figure 5a. The correlation between data and predictions for the broader measure is 0.60 for $\sigma_2 = 2.3$ and rises to 0.63 for $\sigma_2 = 1.5$.

In contrast, the marketization of other services is explained well by the different tax rates, with the exception of Korea, which is an outlier because of its extremely high market hours in sector 3. But even with Korea included in the predictions, the correlation coefficient between data and predictions for $\sigma = 2.3$, as shown in Figure 5b, is 0.73.

8 Conclusions

We summarize the main findings as showing that the large differences in the allocation of market work across the countries of the OECD can be attributed to the differences in taxation, the subsidization of social work and the market-home production substitution. Taxes and subsidies cause substitutions along two dimensions, across market goods because of different tax rates applying to different goods , and between market and home production because home production is neither taxed nor subsidized. The interaction between these two margins explains both the quantitative impact of policy and the asymmetric response of different sectors to the taxes and subsidies; in particular the fact that the main differences in the allocation of hours of work across countries are in health and social work and in unskilled services. The market-home production substitution is the key explanation to the asymmetric response, because of the different substitution possibilities between market and home work across goods and services.

We demonstrated these claims by making use of data on taxes and social expenditure from the OECD, home production data from time use surveys, and disaggregated data on hours of work by sector. We were able to do this

indistinguishable from the predictions with $\sigma_2 = 2.3$.

[21] Several writers have written about the differences in the way that OECD citizens view the role of social care and family-related work in the home and the market, so differences in tastes may play a role here. See for example, Gosta Esping-Andersen (1990, 1999), and Yann Algan and Pierre Cahuc (2009).

for nineteen OECD countries with favorable results.

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Figure 1. Percentage distribution of hours of work, 1994-2003, sorted according to sector 2 size

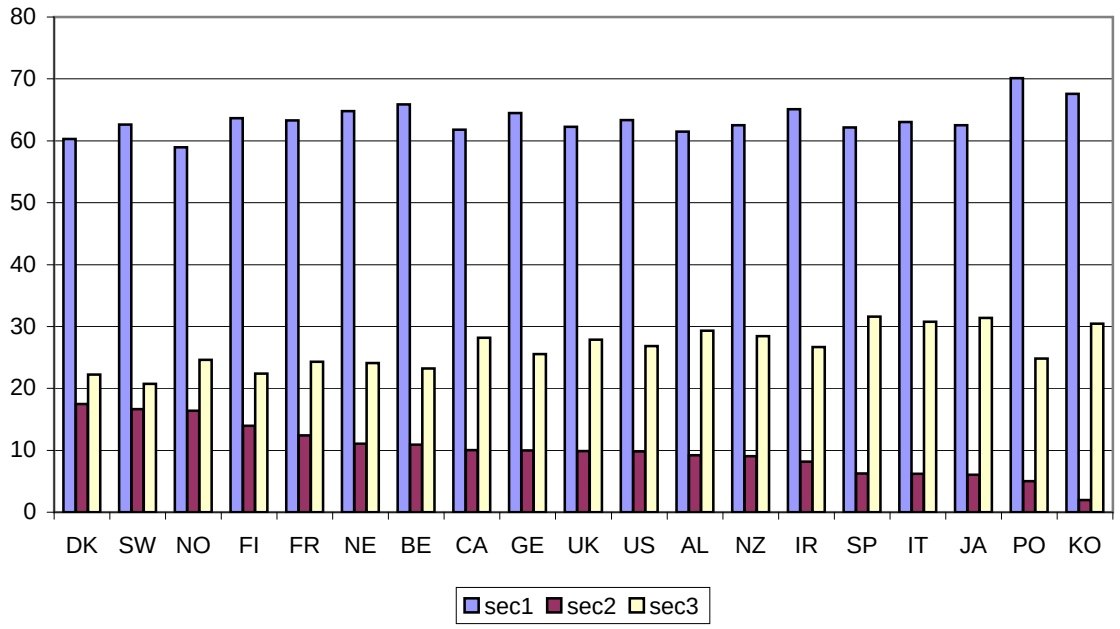


Figure 2. The calculated tax wedge, 1994-2003, sorted according to the differential between the two rates (social subsidies only)

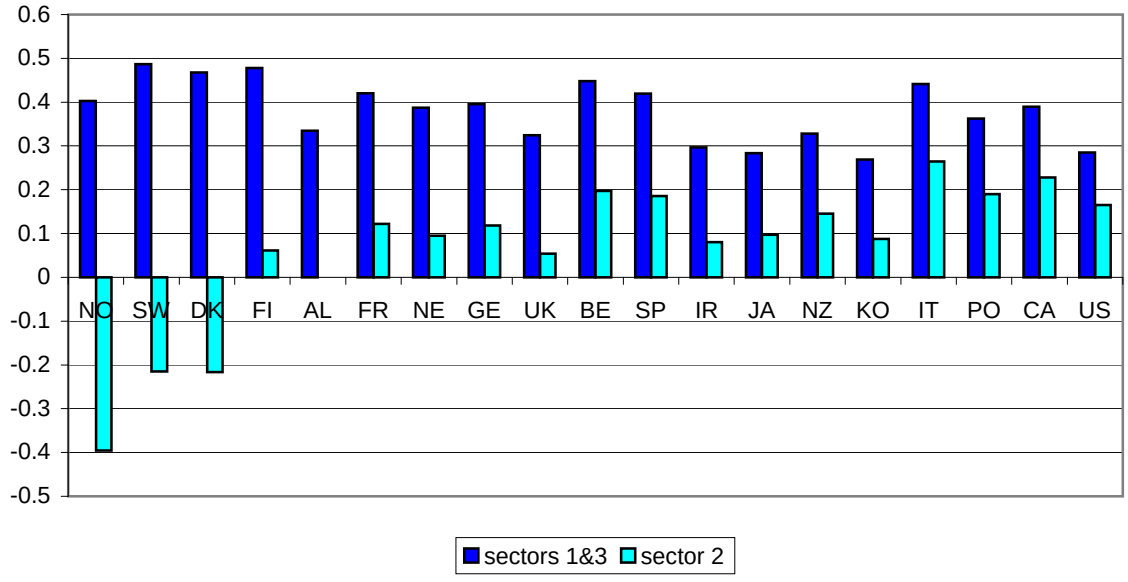


Figure 3a Predicted impact of taxation, share of health and social care sector

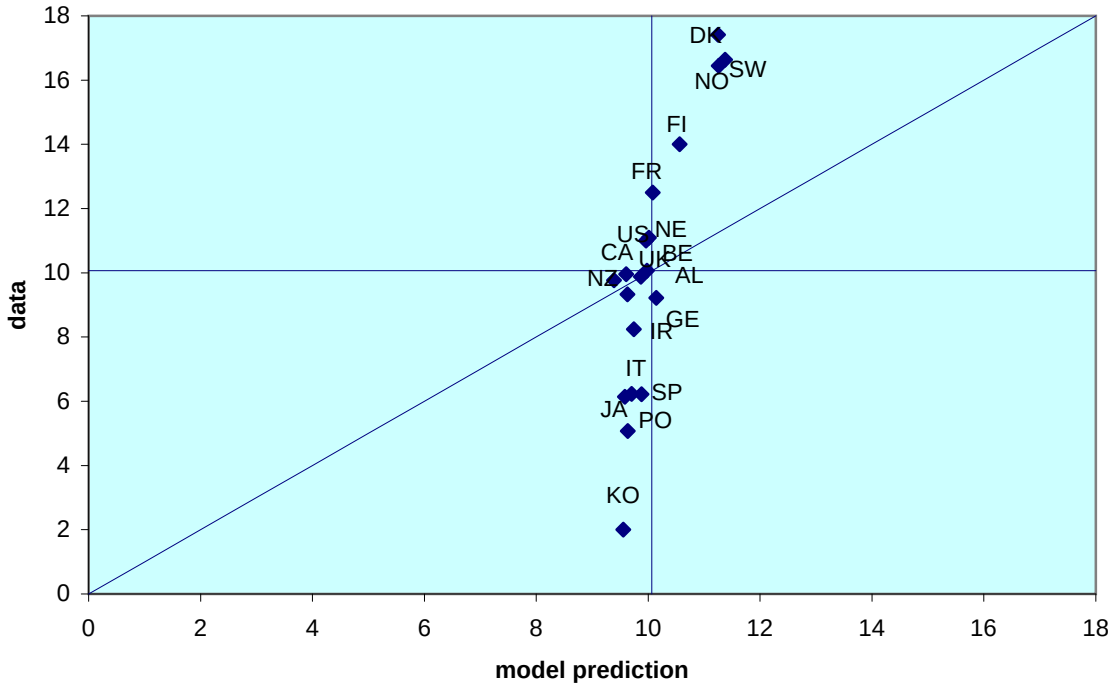


Figure 3b Predicted impact of taxation, share of health and social care sector, epsilon 1.5

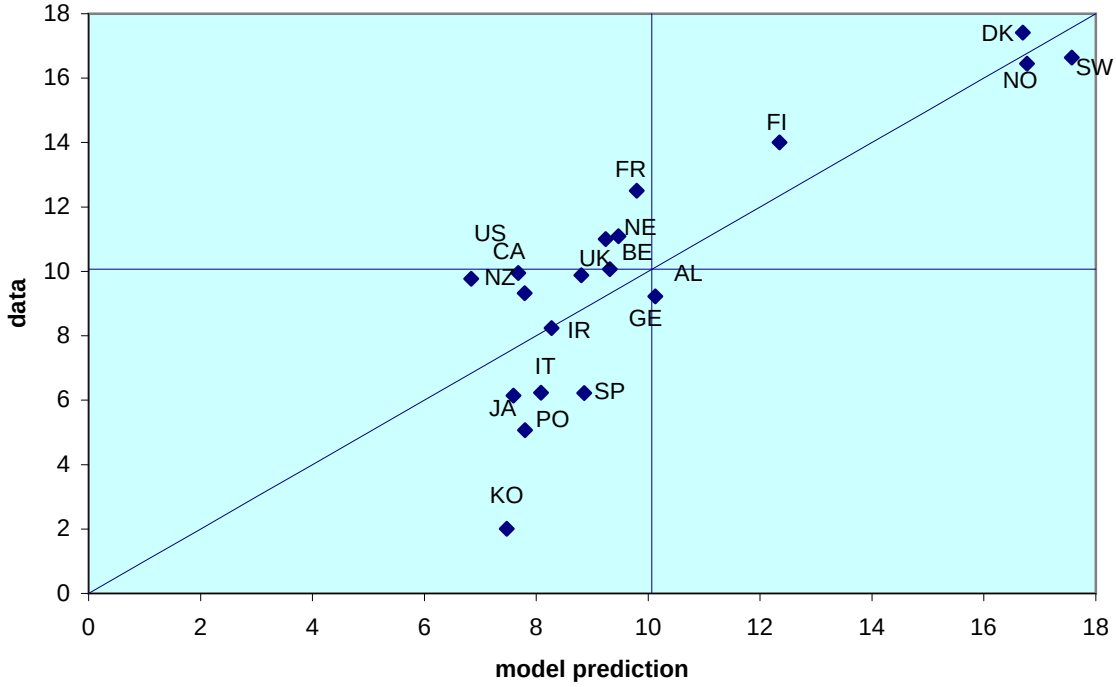


Figure 4a
Predicted sector 2 share, home production exogenous

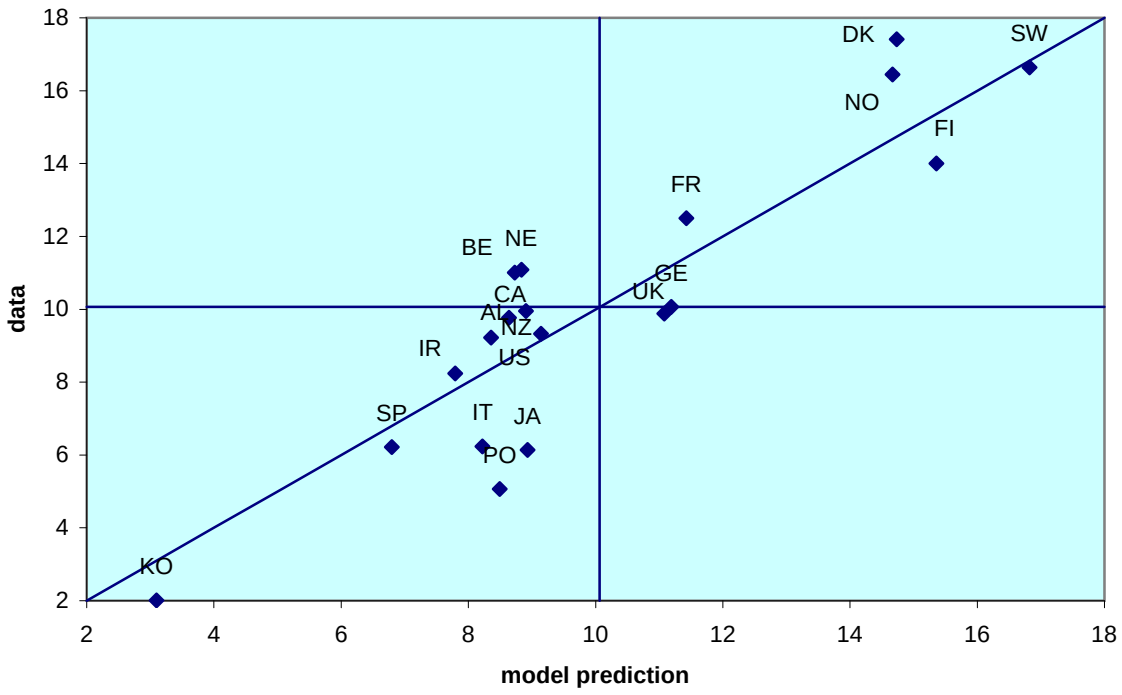


Figure 4b
Predicted sector 3 share, home production exogenous

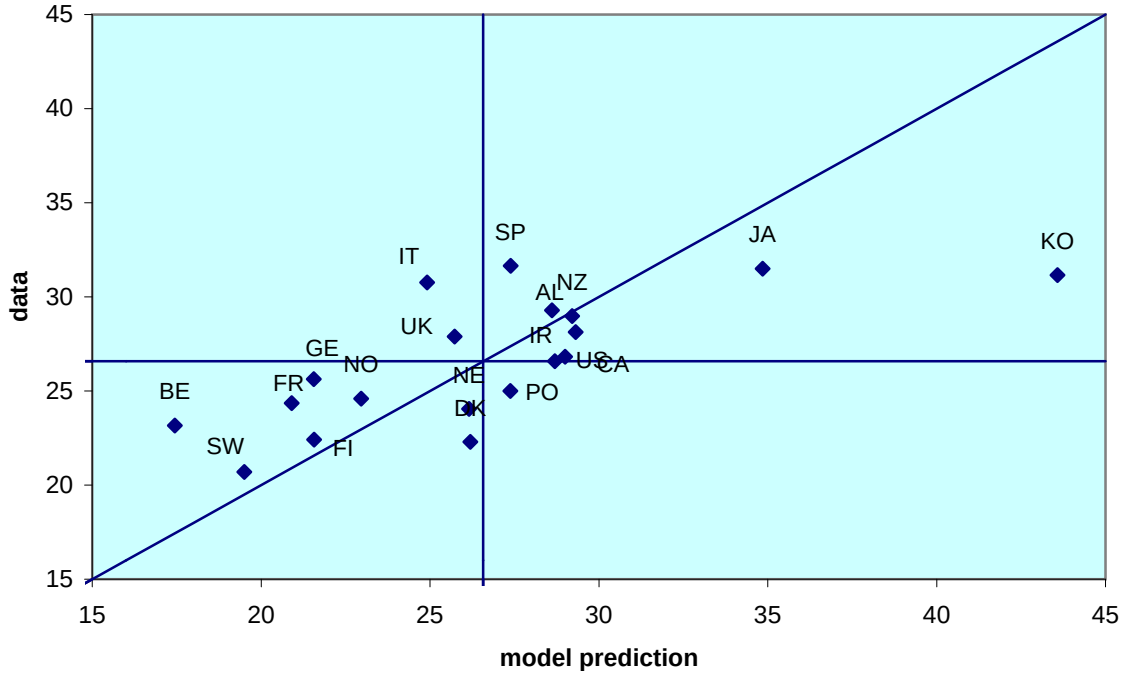


Figure 5a
Actual and predicted marketization in health and social work

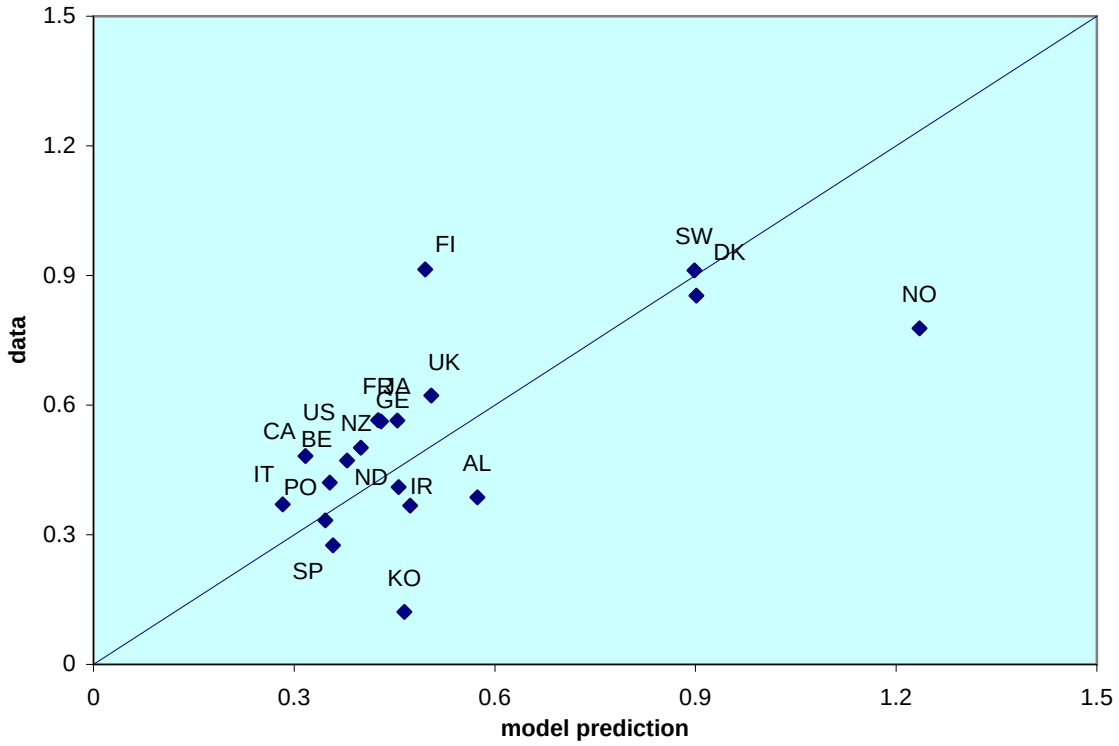
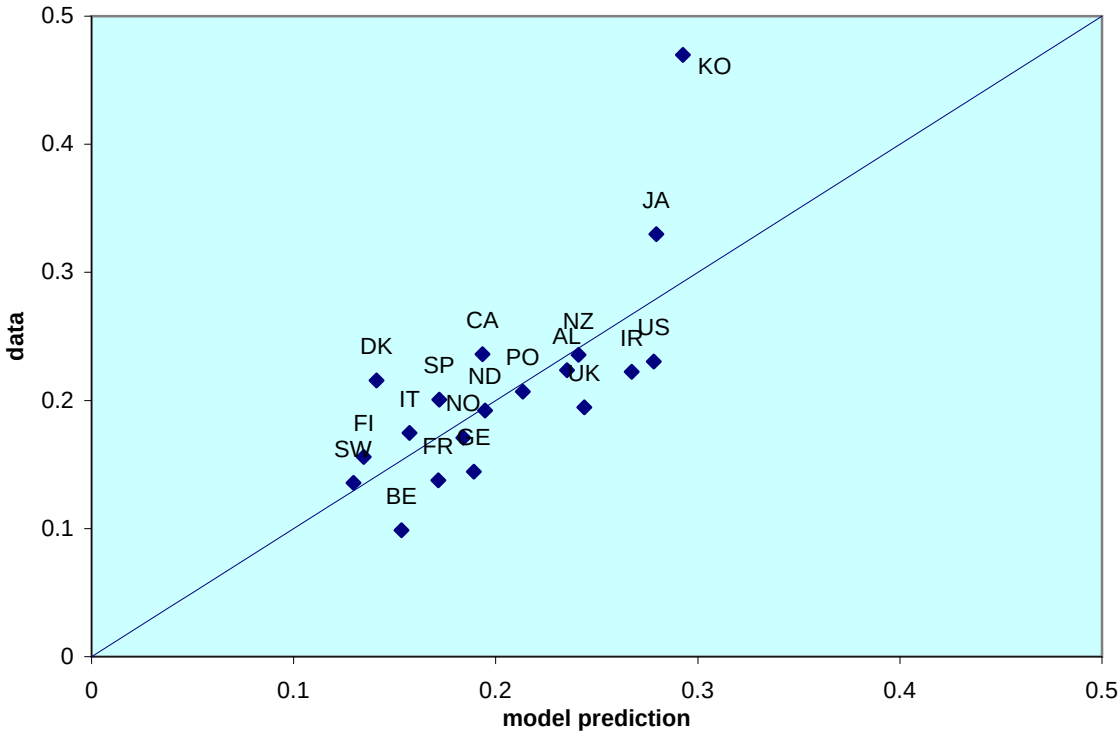


Figure 5b
Actual and predicted marketization in other services



Taxes Social Subsidies and the allocation of Work Time
L. Rachel Ngai and Christopher A. Pissarides
Web Appendix

1 Data sources and construction

The paper uses data for 19 OECD countries: Australia, Belgium, Canada, Denmark, Finland, France, Germany, Ireland, Italy, Japan, Korea, Netherlands, Norway, Portugal, Spain, Sweden, U.K., U.S., New Zealand. This Appendix provides the data sources.

Time use data

Time use data record activities at regular intervals (e.g. every 15 minutes) during a 24-hour day. For the purposes of this paper we extracted from time use surveys two numbers, time spent on caring for a child or an adult household member, including related travel time, and other home work time.

Home work in time use surveys includes activities that could be delegated but are done by members of the household, either inside or outside the home. The main activities are shopping, house and garden cleaning and maintenance, cooking, laundry, pet care and car care. Travel time is included with the corresponding activities, e.g. travel time to shops is included in shopping. Childcare is a separate item. Caring for others within the household is a separate item, although some surveys at our disposal did not report separately this item. The item is small, accounting for less than 20% of childcare time, and where missing we constructed a series for it from other information, as explained below. Caring for others outside the family was reported separately by a very small number of surveys but we could not get data for it for most countries. Where reported it was a very small item. Most surveys included it with other small activities in "other voluntary work", a small item that is part of other home production time.

The main data source for the European countries is the *Harmonised European Time Use Survey* (HETUS: https://www.testh2.scb.se/tus/tus/). It was the result of a cooperation between a number or national statistical institutes and Eurostat in the 1990s, with the objective to harmonize time use statistics in the European Union. The HETUS covers 9 of our 19 countries around the year 2000. They are Belgium (1998), Finland (1999), France

(1998), Germany (2001), Italy (2002), Norway (2000), Spain (2002), Sweden (2000, age group 20+) and the United Kingdom (2000). Detailed national tables for each country are downloadable from the HETUS website. Each national table reports time use of population by age. We compute the time use for the 15+ category by weighting each group by its population size, using population data from the United Nations, *World Population Prospects* (http://esa.un.org/unpp/index.asp?panel=2).

The HETUS does not report explicitly the time taken for caring for household members. We obtained accurate data from the national source used by HETUS for Finland, Germany, Norway, Spain, and the United Kingdom. For the other countries HETUS reports a residual aggregate of "other household work," which includes caring for others as one of the main items. For Belgium and Italy we used Spain's ratio of "caring for others" to the HETUS "other household work" to get the time of caring for others from the HETUS residual. For France the HETUS residual was clearly misreported, as it was 1 minute a day for all age groups. We increased France's childcare time by Spain's fraction of caring for others to childcare. Finally, for Sweden we used the average decomposition of "other household work" for Norway and Denmark to obtain the time for caring for others from the HETUS aggregate.

For the remaining 10 countries, we use national time use statistics, as follows (in some cases, as indicated below, it was not possible to obtain data for the 15+ category but for a near age group):

Australia: 1997 Time Use Survey conducted by the Australian Bureau of Statistics (ABS). Tables are available from the publication, *How Australians Use Their Time 1997*, available online through http://www.abs.gov.au/AUSSTATS.

Canada: *General Social Survey* (GSS) conducted by Statistics Canada in 1998 and available online through http://www.statcan.gc.ca/. Adult care is included in a residual "other household work". We used the US fractions to decompose this item into caring for others and other items.

Denmark: Data are available only in Danish for 2001, age groups 15-74, translated and tabulated for this paper by Jens Bonker of the Rockwool Foundation Research Unit, Copenhagen (to whom we express our thanks).

Ireland: The *Irish National Time-Use Survey 2005* is a pilot survey conducted by Economic and Social Research Institute for the Department of Justices, Equality and Law Reform. We obtained the time use table from the publication, *Time-Use in Ireland 2005: Survey Report*. Age group 18+. (http://www.ucd.ie/issda/dataset-info/timeuse.htm)

Japan: The 2001 Survey on *Time Use and Leisure Activities* conducted

by the Statistics Bureau, Ministry of Internal Affairs and Communications. (http://www.stat.go.jp/english/data/shakai/2001/unpaid/tabu.htm)

Korea: Data provided for this paper by the Korea Labor Institute, Seoul, following a visit by one of the authors in 2008 (C Pissarides). Data for 1999, age group 10+ (data also available for 2004 with virtually identical results).

Netherlands: Netherlands Institute for Social Research. At the time of writing detailed tables were available online in English but now discontinued. We obtained our aggregates from Burda et al. (2008), age group 20-74.

New Zealand: *Time Use Statistics 1999* prepared by Statistics New Zealand, tables downloaded from: http://www.stats.govt.nz/. Only total family care is available (childcare and adult care).

Portugal: *1999 Time Use Survey*, conducted by Instituto Nacional De Estatistica (INE). Table and document (in Portuguese) are downloadable from: http://www.ine.pt/

United States: *The American Time Use Survey 2003* by the Bureau of Labor Statistics (http://www.bls.gov/tus/).

Hours of work

Sectoral hours were obtained mainly from the database *Productivity in the European Union: A Comparative Industry Approach* (EU KLEMS), http://www.euklems.net/, file extension .08I, released March 2008. The following KLEMS sectors are in each one of our sectors:

Sector 1 includes KLEMS Sectors A (agriculture, hunting, forestry), B (fishing), C (mining and quarrying), D (manufacturing), E (electricity, gas, water), F (construction), G51 (wholesale trade), I62 (air transport), I64 (post and telecommunications), J (financial intermediation), K (real estate, renting and business services), O91 (activities of membership organizations nec) and O921t2 (media activities)

Sector 2 is the KLEMS sector N (health and social work)

Sector 3 includes the KLEMS sectors G50 (sale and maintenance of motor vehicles and motorcycles), G52 (retail trade), H (hotels and restaurants), I60 (inland transport), I61 (other water transport), I63 (other supporting travel activities), O90 (sewage and refuse disposal), O923t7 (other recreational activities), O93 (other service activities)

Three countries are not in KLEMS: Canada, Norway, and New Zealand. We constructed their shares from the KLEMS predecessor, the OECD *Structural Analysis Database* (STAN), following the same sector decomposition.

Some data entries are missing. In all cases the missing entries were for very small subsectors. We constructed the missing data series by assuming that the shares of the missing series within its sector were the same as the corresponding shares in neighboring countries with a similar industrial structure. In most cases the missing data were for media activities (sector O921t2). The "similar" country shares used to construct the media sector in the countries that it is missing were selected as follows: for Denmark we used the media's hours share for Finland. For Italy we used Spain's. For Japan we used Korea's. For the Netherlands we used the UK's. For Sweden we used Finland's. The size of this sector affects the allocation of sector O92 into O921t2 (which belongs to sector 1) and O923t7 (which belongs to sector 3). However, given this sector is rather small (it is less than 2% of sector 1 or 3 in all the above countries), alternative ways of imputing its size does not alter the size of sector 1 and 3 and so our results are not sensitive to this imputation.

STAN does not have a breakdown of hours for New Zealand but it has total hours. We obtained employment data for industrial sectors by status (part time or full time) from the website of Statistics New Zealand, to calculate the shares of employment in individual sectors (weighting part-time employment by 25/40), and then multiplied these shares by total weekly hours for the 15+ population to obtain hours in each sector.

For Canada no data are available for the decomposition of sector O, we use US's shares to allocate hours within sector O sub-sectors. Similarly for Norway, we used Finland's shares to allocate total sector O hours to its components.

The population aged 15 and above that was used to derive per capita hours was obtained from *World Developments Indicators.*

Taxes

The tax rates were calculated from the data given in Nickell (2006), the OECD/CEP data set. Briefly, they are as follows.

The employment tax rate is defined as ESS/(IE-ESS), with ESS equal to employers' social security contributions and IE equal to total compensation for employees. ESS is available from the OECD *National Accounts* and IE from the OECD *Revenue Statistics.*

The direct tax rate is defined as DT/HCR, with DT equal to income tax plus employees' social security contributions and HCR equal to household

current receipts. Income tax and employees' social security contributions were taken from the OECD *Revenue Statistics*. HCR was calculated from the OECD *National Accounts* as the sum of compensation of employees, property income, social contributions and benefits and other current transfers.

The indirect tax rate is defined as (TX-SB)/CC, with TX equal to indirect taxes, SB equal to subsidies and CC household final expenditures. All three were taken from OECD *National Accounts*.

For the employment subsidy we obtained total spending on active labour market measures (code 600) from the OECD *Social Expenditure Database* (SOCX) and divided it by total employee compensation from KLEMS. Data are missing for New Zealand, and we set this rate at the Australian rate (generally, this is a very small number for all countries).

The rates used in the paper were averages for 1994-2003. Most countries had complete data sets and all countries had at least some entries for those years, which were used to arrive at averages. The only exception is Korea, for which there were no tax data at all. For this country only we used the tax data available at the OECD *National Accounts: Korea.*

Social subsidies

The social subsidies are available in SOCX, 1980-2003, released 2007. We use data for 1994-2003. Social expenditure are given as a percentage of each country's GDP. We multiplied by GDP from the OECD *National Accounts* to obtain the absolute amounts, and then divided by the gross output of the health and social work sector, available in KLEMS, to obtain the rates. The value of "benefits in kind" for the following social expenditure categories were aggregated to arrive at the social subsidy: old age (code 120), incapacity (code 320), and family (code 520). In all these categories the benefits in kind were for residential or day care and home-help services. The common feature uniting these items was that the employees delivering these "benefits in kind" worked in the health and social work sector. These three series are complete for all countries except for Canada and U.S. In the case of Canada, both old age and incapacity benefits in kinds are missing, so our subsidy includes only family benefits in kind. In the case of the U.S., incapacity benefits in kind are missing. Our broader health and social subsidy adds half of total spending on Health care, (code 420), also available in SOCX.

2 More results on aggregate hours

Time use surveys record "market work" as the aggregate of the number of hours spent at the place of work, time taken to travel to work and any other activities related to market work, such as working at home in evenings or weekends, job search, reading literature connected with the job etc. For this reason market work reported in time use surveys exceeds hours of work reported in household or employer surveys. In the countries of our sample the average difference between market work reported in time use surveys and the total hours reported by employers over a comparable period of time (and including government employment and education) is 27%, with standard deviation 13%. Table A.1 shows the percentage distribution of total hours of work between market and home, making use of the same source, time use surveys. The table shows wide variations across countries, with the central and southern European countries having the smallest percentages of market hours and the two Asian countries the largest market shares.[1]

[1]The ranking of countries is roughly the same if market hours are measured by EU KLEMS and other employer-based surveys. The only noteworthy difference is that Scandinavian countries report more market-related work at home than the other countries in the sample. The correlation coefficient between the market share reported in Table **??** and the one obtained from KLEMS is 0.9.

Table A.1:
The percentage distribution of total hours of work between market and home

Country	market	home	Country	market	home
Belgium	38	62	Spain	47	53
Germany	41	59	Netherlands	48	52
Italy	43	57	Norway	50	50
France	44	56	Canada	50	50
Finland	45	55	USA	51	49
Australia	45	55	Portugal	53	47
New Zealand	46	54	Denmark	56	44
UK	46	54	Korea	58	42
Ireland	46	54	Japan	60	40
Sweden	47	53			

As an alternative to our preferred measure of the absolute number of hours of work in sectors 2 and 3, we computed an alternative where we used the EU KLEMS sector weights to compute their hours from the total number of market hours reported in time use surveys. This procedure has the advantage that both sets of hours (home and market) come from the same source but it assumes that commuting and home preparation related to one's job is the same across all sectors of economic activity. As this is not likely to be the case (for example, we expect more time spent at home preparing for work by professional people than by workers in unskilled services) we place more confidence in the first of our two marketization series, the one that uses the employer survey for market hours, and this is the one that we report.[2] Results, however, are very similar with the two series, which is not surprising given the high correlation between the two marketization series. The correlation between the marketization in sector 2 computed with EU KLEMS data and the one computed with time use data is 0.98, and the same correlation for sector 3 is 0.94.

3 Sensitivity analysis

Our baseline results use $\sigma_2 = \sigma_3 = 2.3$. This section considers σ_2 and σ_3 ranging from 1.1 to 10. The results are similar to our baseline results. For the baseline, the correlation between the data and the predicted values of l_2/l_1 and l_3/l_1 are 0.89 and 0.55 respectively. Table A.2 reports the corresponding correlation for alternative values of σ_2 and σ_3.

[2] Another problem with the series that uses the time use survey for market hours is that measurement errors lead to higher negative correlations between market hours and home hours. For example, if commuting time for work is misclassified as commuting time for home production, reported home production time rises and market hours fall. But if we use an employer base for market hours, the misreporting of home hours does not impact on the reporting of market hours. We put the model through a more stringent test by taking market hours and home hours from different sources. (Confirming this, results are very slightly better with the marketization data computed from the time use surveys.)

Table A.2: Sensitivity Analysis

σ_2	$\frac{l_2}{l_1}$	σ_3	$\frac{l_3}{l_1}$
1.1	0.898	1.1	0.565
1.5	0.894	1.5	0.557
2.3	0.890	2.3	0.551
5	0.886	5	0.544
10	0.884	10	0.541

Comparing Figure 4a, Figure A.4a_1 to Figure A.4a_4 report the predicted l_2/l_1 against the data for alternative values of σ_2. Comparing to Figure 4b, Figure A.4b_1 to Figure A.4b_4 report the predicted l_3/l_1 against the data for alternative values of σ_3.

Figure A.4a_1
Predicted sector 2 share, home production exogenous
Sigma 2 = 1.1

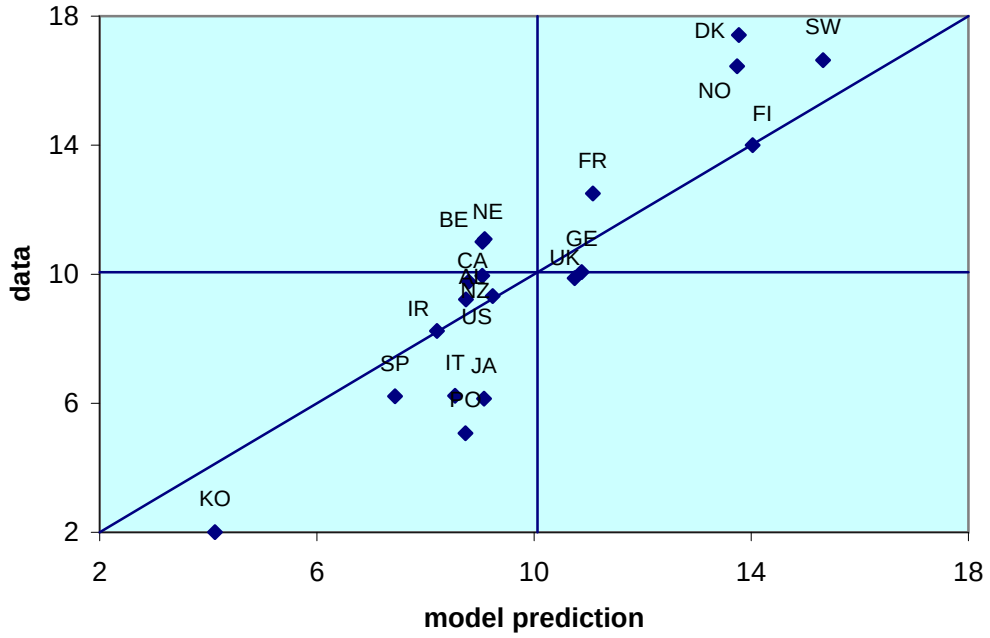


Figure A.4a_2
Predicted sector 2 share, home production exogenous
Sigma 2 = 1.5

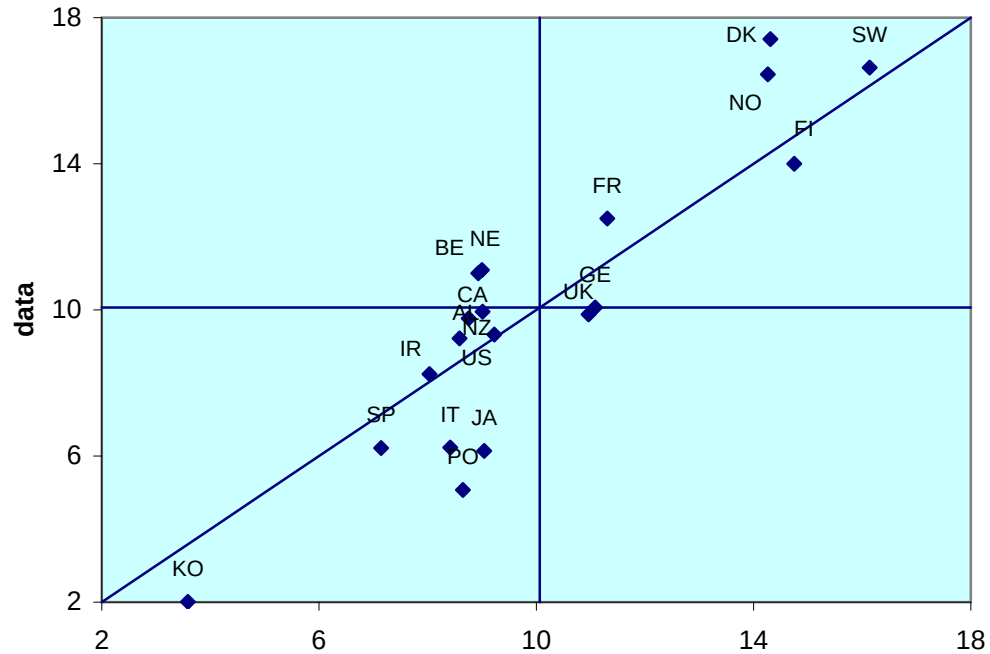


Figure A.4a_3
Predicted sector 2 share, home production exogenous
Sigma 2 = 5

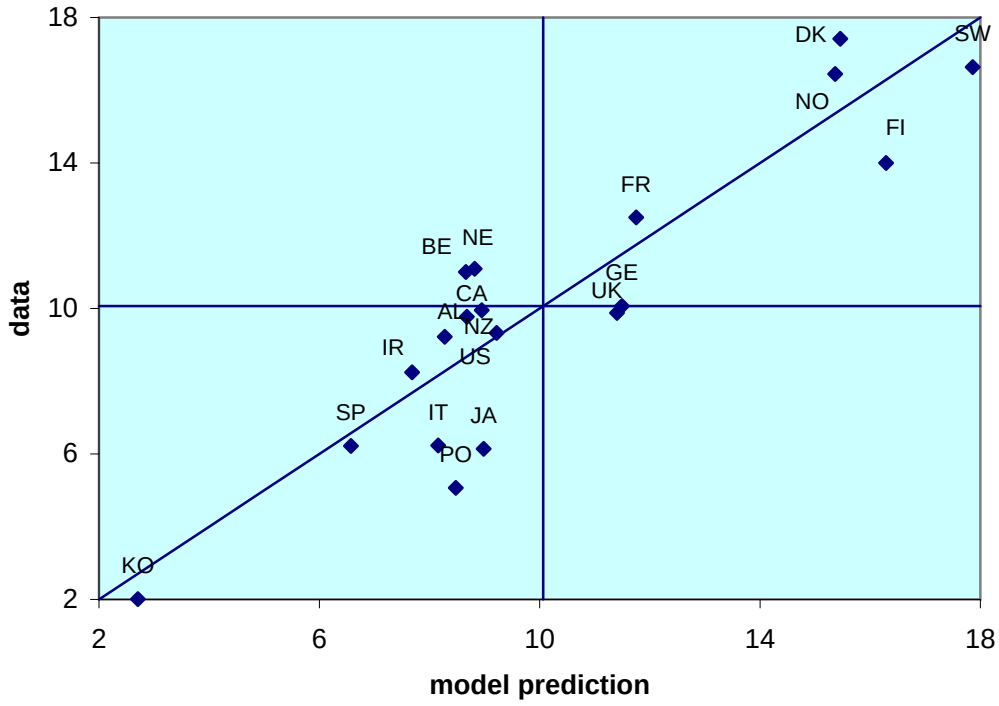


Figure A.4a_4
Predicted sector 2 share, home production exogenous
Sigma 2 = 10

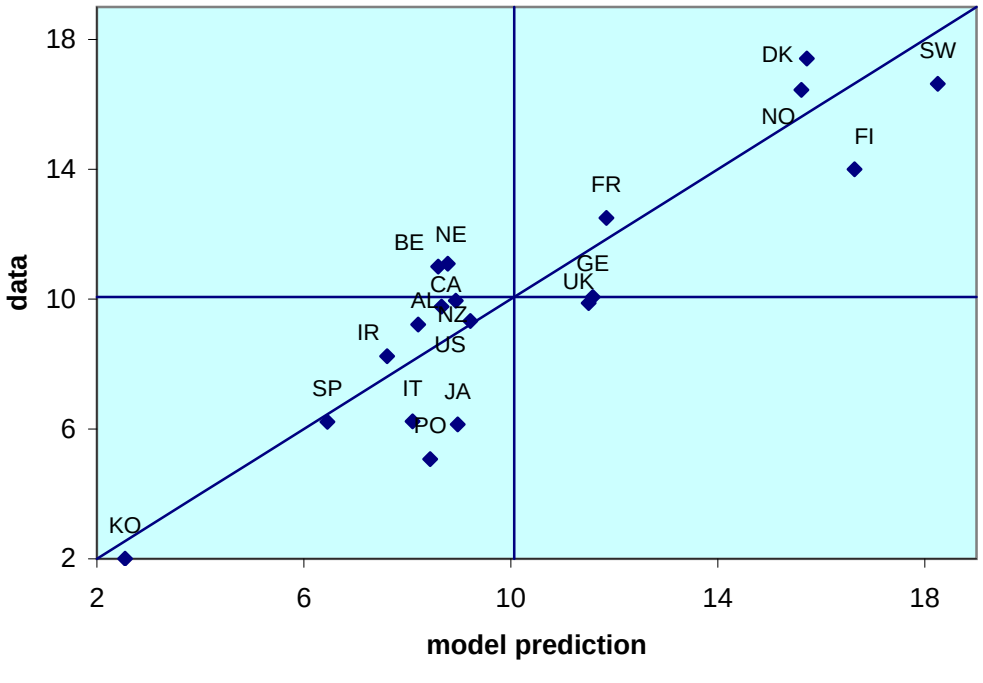


Figure A.4b_1
Predicted sector 3 share, home production exogenous
Sigma 3 = 1.1

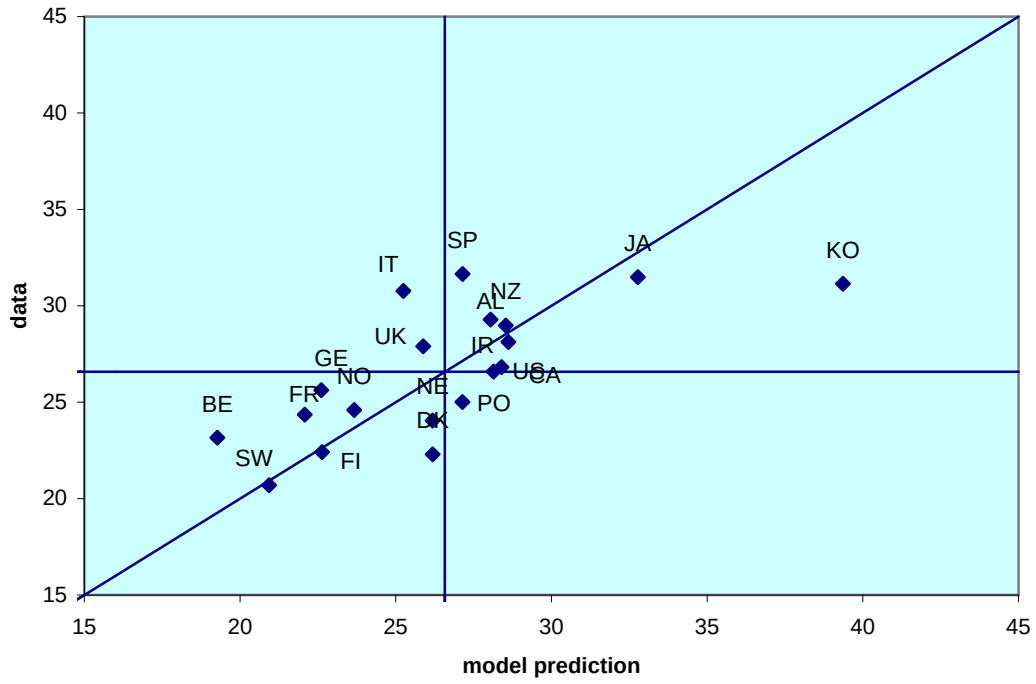


Figure A.4b_2
Predicted sector 3 share, home production exogenous
Sigma 3 = 1.5

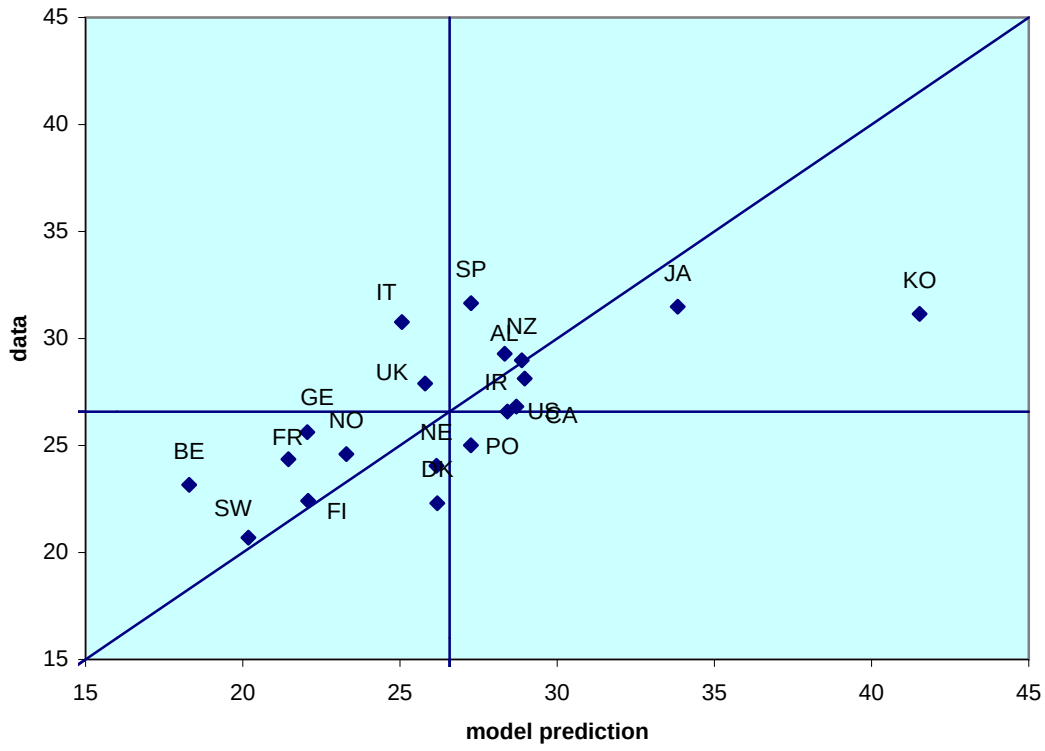


Figure A.4b_3
Predicted sector 3 share, home production exogenous
Sigma 3 = 5

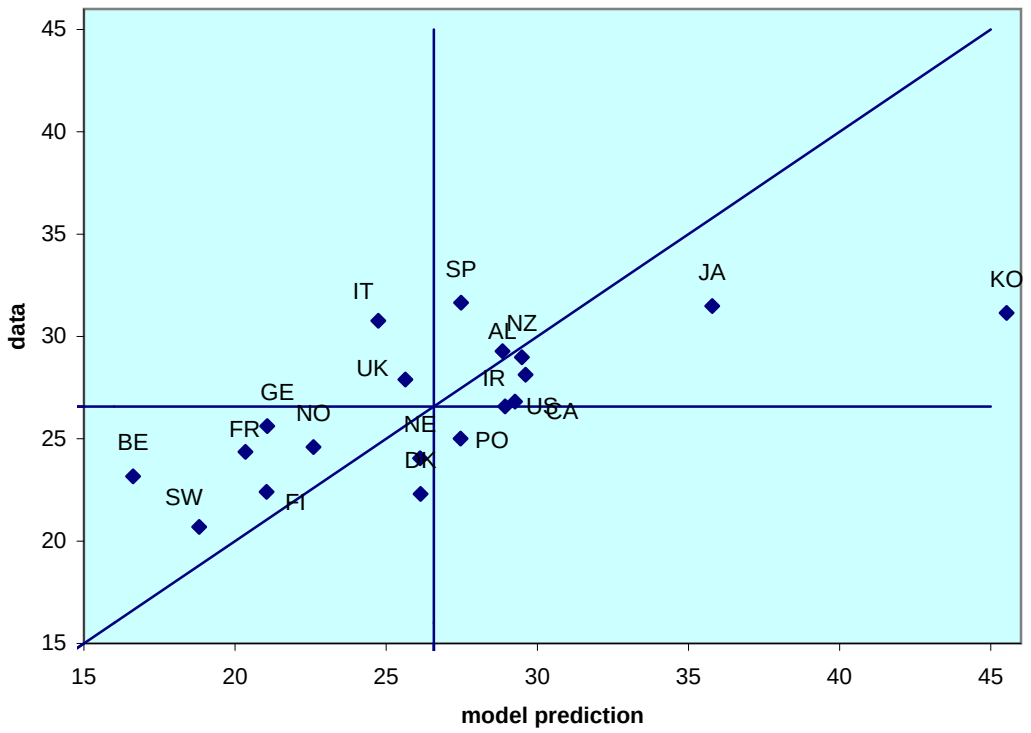


Figure A.4b_4
Predicted sector 3 share, home production exogenous
Sigma 3 = 10