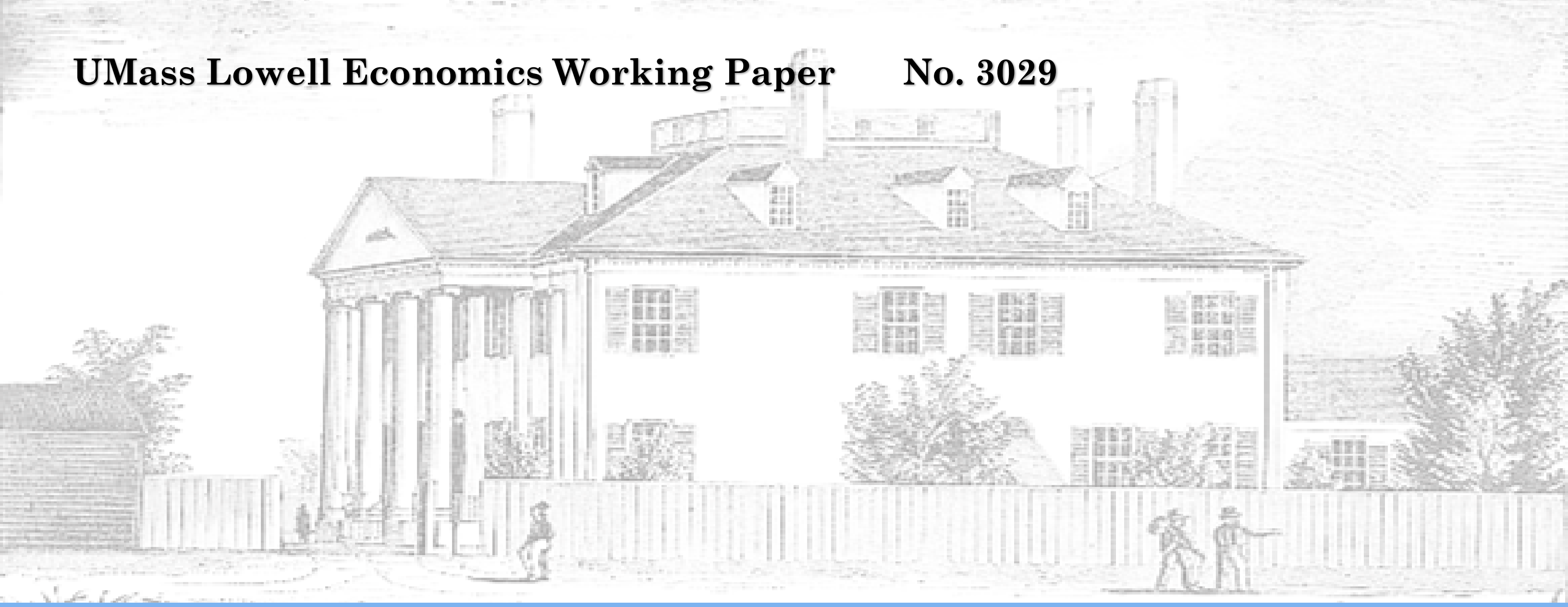
UMass Lowell Economics Working Paper No. 3029



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April 3, 2021

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What Drives Trends in Employment and Hours Worked per Worker? A Cross Country Analysis*

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Abstract

Hours worked are fundamentally important for aggregate economic activity, and their long run trends diverge considerably in Europe versus the United States. Yet, canonical macroeconomic models—even tax-inclusive ones—fail at replicating these differing trend behaviors. We develop a simple extension of the canonical macroeconomic model that decomposes trend hours into extensive and intensive margins via household-side employment-attainment costs and firm-side employment adjustment costs. Predictions of a tax-inclusive version of this model track very well the trend behavior of hours and its two underlying margins in both the United States and a host of European countries. The model shows that taxes and, in particular, capital taxes, impact the two margins of labor quite differently. Therefore, if these margins are not disentangled the full impact of taxes on work hours does not come through. The model has implications related to the relative rigidity of labor markets across countries and also to international risk sharing that are in line with the data and, therefore, validate its structure. The model's success in tracking work hours in a range of countries suggests that it can be used as a laboratory to study a broad set of issues regarding the trend behavior of labor markets.

JEL Codes: E60, H20, J20. **Keywords**: hours worked per population; international risk-sharing wedge; labor-market policy; long-run labor wedge; taxes; U.S. tax puzzle.

* **Declarations of interest: none.**

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1 Introduction

Hours worked per population (H) are fundamentally important for aggregate economic activity. The contemporary, canonical, macroeconomic model serves as a common framework that can get at the fundamental driving forces associated with the behavior of H.[1] Using this common framework led to notable progress in accounting for the short run (business cycle) behavior of H while still remaining in the representative agent paradigm, for example, by extending the model to incorporate search frictions or indivisible labor.[2]

In contrast, there has been relatively less progress in accounting for the long run (trend) behavior of H. In particular, the canonical model cannot explain well-known and notable international differences in the long run behavior of H. Of the many avenues explored to remedy this shortcoming, a very promising and tractable one was to extend the canonical framework to account for effective taxes in the spirit of Mendoza, Razin, and Tesar (1994), who argue, in line with other earlier work, that these types of taxes are the appropriate ones for a representative agent framework. Using these effective taxes Prescott (2004) and Ohanian et al. (2008) find that the tax-inclusive canonical model's predictions for Europe are substantially better than those of its tax-exclusive counterpart. However, these authors also find that the tax-inclusive model yields starkly counterfactual results for the US, in fact substantially worsening the tax-exclusive canonical model's predictions in this case. *We henceforth refer to this issue as the "U.S. tax puzzle."*

Figure 1 illustrates these facts by plotting empirical H and H predicted by tax-exclusive (canonical H without taxes) and -inclusive (canonical H with taxes) versions of the canonical model for Europe and the US. The figure shows that in the face of large changes in works hours both in the US and Europe, hours predicted by the canonical model without taxes are practically flat. The canonical model *with* taxes,

[1] That is, a dynamic, perfectly competitive, micro founded, and representative agent model cast in real terms, as in the seminal work of Kydland and Prescott (1982).

[2] Diamond (1982) and Mortensen and Pissarides (1994) are key references regarding search frictions, and Hansen (1985) and Rogerson (1988) are so regarding indivisible labor.

on the other hand, is able to track the trend decline in hours in Europe, but predicts a (counterfactual) trend decline in US hours.

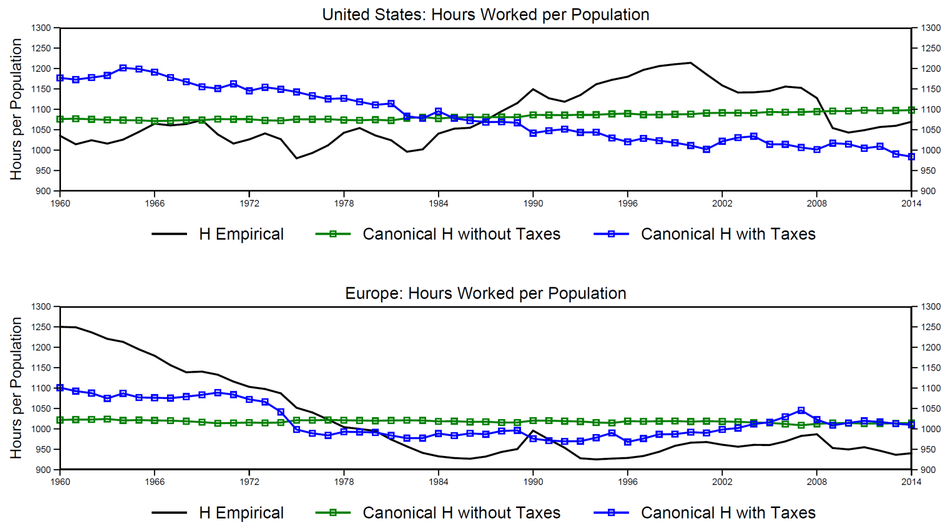

Figure 1: Empirical hours worked per population and predictions from CLM model with and without taxes for Europe (top panel) and the US (bottom panel).[3]

To date, the U.S. tax puzzle remains unresolved. This lack of resolution is of critical interest because it potentially casts doubt on the appropriateness of effective tax rates as a tool for reconciling the canonical model with the data. Indeed, a satisfactory framework to address the long run behavior of H must track international developments in H (including in Europe and the US) in a consistent manner.

Against this backdrop, in this paper we seek an answer to the following question: what factors drive the U.S. tax puzzle, and can it be resolved? Our results suggest that the issue lies with the model, not taxes. In particular, we show that a novel yet tractable extension of the canonical macroeconomic model that disentangles the extensive and intensive margins of labor hours can, accounting for taxes, successfully explain the long run behavior of H in both Europe and the US. Therefore, taxes are indeed critical for explaining the long run behavior of H, but so is building up H

[3]Notes: All data are at yearly frequency. Total work hours are from the Conference Board's Total Economy Database, employment is from the OECD, population data are from the UN, tax data are from McDaniel (2007), and consumption and output data are from the Penn Word Tables. "Europe" refers to the simple average of European countries in our sample. Sample countries, which are standard in related literature, and data span are limited by the availability of time series on taxes. Details are in the paper's data and theory sections.

endogenously from the ground up by modeling the determination of hours worked per worker (h) and the employment-population ratio (e) separately. Importantly, the model shows that taxes and, in particular, capital taxes, impact the two margins of labor quite differently. Therefore, if these margins are not disentangled the full impact of taxes on H does not come through.

The intuitive and tractable extension of the canonical model that we propose has two key features that distinguish it from the canonical model and results in the disentanglement of h and e. First, the presence of employment-*attainment* costs on the household side, which enter the model in the form of disutility. Second, the presence of firm-side employment *adjustment* costs. The remainder of our framework is in line with the canonical model, in particular the fact that our model is frictionless, assumes fully flexible prices, and is grounded within the representative agent framework.

The two modelling devices listed above are well known in the literature. However, their inclusion in a model with taxes on labor and capital has novel empirical implications for which we find support in the data (these implications are discussed later). Importantly, key parameters of our model that we structurally estimate using cross-country data, such as those governing the degree of employment adjustment costs faced by firms, are intuitively in line with well-known differences in the rigidity of labor markets across countries and hence add to the internal validity of the model.

Because our model disentangles the two margins of labor, we refer to it as the dual labor margins (DLM) model. This contrasts with the canonical macroeconomic model, where the only endogenous labor-market variable is H. We refer to the class of models where this is the case as combined labor margin (CLM) models.

Our analysis provides quantitative assessments of the importance of different underlying factors—taxes on consumption expenditures and capital income and labor income, and aggregates such as productivity growth and the consumption-output ratio—that are important for the behavior of the extensive and intensive margins of H, and the role that they play in divergent trends in H across countries. For example, we find that for the US robust gains in total factor productivity over the last decades have been associated with roughly 18 percent higher e. However, despite similar underlying productivity trends in Europe gains in e failed to materialize mainly due to offsetting increases in Europe's labor taxes. This result was not highlighted by earlier literature, as it is only apparent when disentangling the long run behavior of the two margins of labor.

We also explore the model's implications when extended to an open economy framework (of note, earlier most-related literature only focuses on analysis of closed economy models). In this open economy framework, the implied consumption risk sharing condition can be stated in terms of labor market variables. From this vantage point, compared to the CLM model, our DLM model's conclusions regarding risk sharing are substantially more in line with those obtained from traditional consumption-based measures of international risk sharing (including those that take taxes into account, such as Epstein et al., 2016).

Moreover, our model helps explain a new stylized fact that we document and, in principle, is perplexing. In the data, at yearly frequency there is a positive contemporaneous relationship between capital taxes and employment (i.e. higher capital taxes are related to higher employment rates). Of course, it is intuitive to expect the contrary. However, our model suggests that this relationship, which is in principle puzzling, is not causal. This result is instead an observed outcome stemming from forward-looking optimal e demand. From this vantage point, in line with intuition, higher capital taxes put downward pressure on e demand. We confirm that this is the case in the data. This finding is, to our knowledge, novel.

Our paper contributes to the literature by proposing a largely satisfactory resolution of the U.S. tax puzzle. In particular, using a business cycle accounting approach following related literature, we find that the model can account very well for the trend behavior of both h and e, and therefore H as well, across a large set of European countries and the United States as well. Our analysis suggests that the U.S. tax puzzle emerges as a consequence of not accounting distinctly and simultaneously for the two margins labor. This is important, because, as we show, major forces such as taxes and productivity can have marked impacts on each margin separately. Jointly, these distinct impacts translate into larger effects on H. While a resolution of the U.S. puzzle is of interest in and of itself, our results suggest that our DLM model can also be used as a laboratory for studying the trend behavior of H in wide range of countries, both in qualitative and quantitative terms, while staying close to the canonical framework (whose attraction lies in its simplicity). This contribution is especially relevant in light of recently documented empirical patterns in work hours based on newly available data from a large range of countries (see for example, Bick et al., 2019a and Bick et al., 2019b), in the backdrop of the absence of a simple, tractable, representative-agent model to provide a united explanation for such patterns.

This paper proceeds as follows. Section 2 reviews related literature. Section 3 details the data we use in our analysis and presents some motivating empirical patterns that inform our model. Section 4 focuses on theory and Section 5 discusses its operationalization. Section 6 presents results. Section 7 concludes.

2 Related Literature

Even though our benchmark DLM framework is entirely frictionless, the development of our model begins as a full-fledged general equilibrium labor search model in order to provide theoretical foundations of some key elements of our framework. As such, we build on a vast related literature, including, among others, Diamond (1982), Mortensen and Pissarides (1994), and Merz (1995). Since our baseline DLM specification is purged of all frictions, our work is also related to existing studies that consider the extensive margin of labor in frictionless environments, such as Hansen (1985), Rogerson (1987), Bils and Cho (1994), Cho and Cooley (1994), Mulligan (2001), Krusell et al. (2008), Llosa et al. (2014), and Erosa (2016), among others. Our DLM model contributes to these literatures by showing how accounting for household employment-attainment costs and firm-side employment adjustment costs are a means through which the extensive and intensive margins of labor can be easily disentangled in a representative-agent Walrasian framework.[4]

Our work is related in spirit to literature on the labor wedge, that is, the extent to which, in equilibrium, the marginal product of labor differs from the marginal rate of substitution of consumption for leisure. This literature includes, among others, Hall (2009), Shimer (2009), Pescatori and Tasci (2011), Karabarbounis (2014a and 2014b), Cheremukhin and Restrepo-Echavarria (2014), Cociuba and Ueberfeldt (2015), Gourio and Rudanko (2014), and Hou and Johri (2018). In contrast to much of the labor-wedge literature, whose analysis is conducted at business cycle frequency, Prescott (2004) highlights that taxes are a natural candidate to help explain the trend behavior of the labor wedge (what we refer to as the "long-run" labor wedge).

Regarding the long-run labor wedge and taxes, Prescott (2004), Ohanian et al. (2008), and McDaniel (2011) are particular instances in which fairly standard tax-inclusive versions of CLM models are used for the purposes of analysis. In all cases CLM models yield counterfactual predictions for U.S. H (to greater or lesser degree), but successful predictions for H for European countries. This means that even after accounting for taxes, the long-run U.S. labor wedge remains. Importantly, Ohanian et al. (2008) note explicitly that the trend discrepancy between empirical H in the United States and hours predicted for the United States by CLM models are so stark that it is a crucial question for future research in macroeconomics.

Yet, in very broad terms, the literature that studies the relationship between trends in taxes and trends in H ends with McDaniel (2011). This impasse in the literature is perhaps the result of it being the case that obvious resolutions to the U.S. tax puzzle are not evident within CLM modeling frameworks. Importantly, our paper highlights that the U.S. tax puzzle can be successfully addressed within a Walrasian representative-agent modeling framework, that is, within the same framework in which the U.S. tax puzzle is originally observed. This stands in contrast with

[4]In our DLM framework, the way in which employment adjustment costs are introduced yields an intuitive relationship between employment and capital taxes. The broader relevance of adjustment costs is emphasized in a vast literature that includes, for instance, Cooper and Willis (2004), Caballero and Engel (2004), Cooper and Willis (2008), and Mumtaz and Zanetti (2014).

papers that highlight the role of heterogeneity for addressing the puzzle, such as Cociuba and Ueberfeldt (2015), who stress the role of gender and marital status. As such, our analysis shows that heterogeneity is, in fact, not necessarily a critical factor for resolving the U.S. tax puzzle.[5]

Finally, we highlight a literature that centers on the fact that, while a positive long-run relationship between productivity and equilibrium e is intuitive and empirically relevant, a definitive theory that links these two variables is lacking. See, for instance, Layard, Nickell, and Jackman (1991), Blanchard (2007), Shimer (2010), and Elsby and Shapiro (2012).[6] Complementing this literature our model suggests that a direct link between changes in total factor productivity (TFP) and equilibrium e can exist by TFP potentially affecting job-formation costs. Our empirical estimates suggest that this is indeed the case and, moreover, that higher TFP lowers job-formation costs, which establishes a long-run positive link between TFP and e.

3 Data and Stylized Facts

Given our focus on the trend behavior of labor market variables, in line with related literature our analysis makes use of data at yearly frequency. The countries in our sample are those for which, also in line with related literature, there is extensive time series data on taxes. These countries are the United States and the following eleven European countries: Austria, Belgium, Finland, France, Germany, Italy, Netherlands, Spain, Sweden, Switzerland, and the United Kingdom. Our analysis spans the years 1960 - 2014, since at the time of writing this paper those are the years over which tax data, which we need to operationalize our model, are available for all of these twelve

[5] Recent papers such as Bick and Fuchs-Schündeln (2018) and Bick et al (2019b) focus on other related dimensions of heterogeneity such as the tax treatment of married couples and educational composition to explain international differences in hours worked. Bick, Fuchs-Schündeln and Lagakos (2018) document wide variation in hours worked with income in a large international cross section of countries, both within and across countries, but do not examine the determinants of long run trends in these variables.

[6] Blanchard (2007) surveys the literature on traditional models of aggregate labor markets and concludes that in these models there is long-run neutrality of unemployment to productivity growth.

countries. As is the case in related literature, our main tax data are average taxes from McDaniel (2007). These data are publicly available from the author's website.[7]

Turning to the additional data needed for our analysis, following related literature we use data on consumption, output, and total factor productivity from the Penn World Tables (Feenstra et al., 2015), which are hosted by the Groningen Growth and Development Center.[8] Data on the working-age population (ages 15-64) come from the United Nations[9], and data on aggregate work hours and aggregate employment come from the Conference Board's Total Economy Database.[10]

Of note, the McDaniel tax series are *average* taxes (see the Appendix for details). For the United States, we are able to assess the sensitivity of results from using these data by comparing them to results obtained using a series on *average marginal* taxes available from the NBER.[11] To the best of our knowledge, there are no comparable tax series for the European countries in our sample. We show that results are similar in terms of trends, but the ability of our model to track contours of the empirical data improves substantially. The main difference between the two labor tax series is that, as shown in Figure 3 below, the McDaniel series do not fully capture the impact of the Reagan tax reforms (1981 through 1986).[12] This influences the extent to which our model can match the contour of H, but is fairly irrelevant for our the model's ability to match the trend behavior of H.

Table 1 presents the notation we use for empirical data through the remainder of paper. In turn, Figures 2, 3, and 4 show the behavior of these data over our sample period. For brevity, in the main text as far as graphical results, we present the only

[7] http://www.caramcdaniel.com/

[8] These data are available for download at https://www.rug.nl/ggdc/productivity/pwt/. Regarding TFP, these data feature, for each country, a TFP index, which is TFP relative to the United States in each period. Of course, then, U.S. TFP is normalized to 1 in all periods. Therefore, we construct U.S. TFP using a standard Solow residual approach and then use the Penn World Tables TFP indices to back out implied TFP levels for all other countries in our sample.

[9] These data are publicly available at https://esa.un.org/unpd/wpp/Download/Standard/Population/

[10] These data can be found at https://www.conference-board.org/data/economydatabase/ While these data are publicly available, at the time of writing this paper accessing the data requires creating an account, which is free of charge.

[11] Tables 1 and 3 from http://users.nber.org/~taxsim/marginal-tax-rates/

[12] NBER tax series is available for a bit shorter time horizon.

for the United States and Europe, where "Europe" refers to the simple average of the eleven European countries in our sample.[13]

Table 1: Notation for Empirical Variables

Notation	Meaning
C/Y	Consumption-output ratio
$1 + C\ tax$	Return-adjusted consumption tax, $1 - \tau^c$ (McDaniel, 2007)
$1 - L\ tax$	Return-adjusted labor tax, $1 - \tau^l$ (McDaniel, 2007)
$1 - K\ tax$	Return-adjusted capital tax, $1 - \tau^k$ (McDaniel, 2007)
$1 - NBER\ L\ tax$	Return-adjusted NBER labor tax
TFP	Total factor productivity
$H\ empirical$	Hours worked per population
$H\ fix\ h$	H holding h fixed at 1960 level ($h_{1960} \cdot e_t$)
$H\ fix\ e$	H holding e fixed at 1960 level ($h_t \cdot e_{1960}$)
$h\ empirical$	Hours worked per worker
$e\ empirical$	Employment-population ratio
$d \ln(x)$	Growth rate of variable x

3.1 Trends in Work Hours and its Drivers

Some highlights follow. First, Figure 2 shows that over the last several decades the main driving force behind the behavior of H in the United states is e, with h being relatively flat.[14] The exact opposite is true of Europe, but with the behavior of e being virtually flat in absolute terms.

[13] On average the patterns for Europe reflect those across the European countries in our sample, so no single country drives the average. Also, results are robust to the averaging methodology including, for instance, GDP-weighted averages.

[14] Rogerson (2006) and Blundell et al. (2011) also broadly highlight these facts.

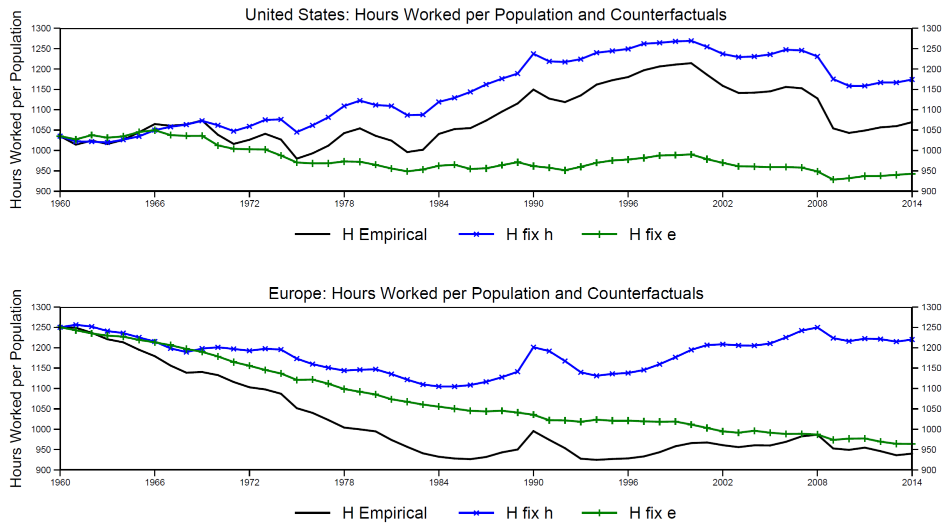

Figure 2: Hours worked per population, per worker, and the employment-population ratio in Europe (bottom panel) and the US (top panel).[15]

Figure 3 shows that in the United States C/Y rose, τ^k decreased, τ^c was fairly flat, and τ^l rose. In Europe, C/Y, decreased, τ^k rose, τ^c rose somewhat as well, and there was a large secular increase in τ^l. Finally, Figure 4 shows that that TFP in the United States and Europe has followed a similar secular increase, with TFP growth slowing in Europe only towards the end of our sample (in this figure Europe's TFP

[15]Note: total work hours are from the Conference Board's Total Economy Database, employment is from the OECD, and population data are from the UN.

in 1960 is relative to that of the United States, which is normalized to 100).

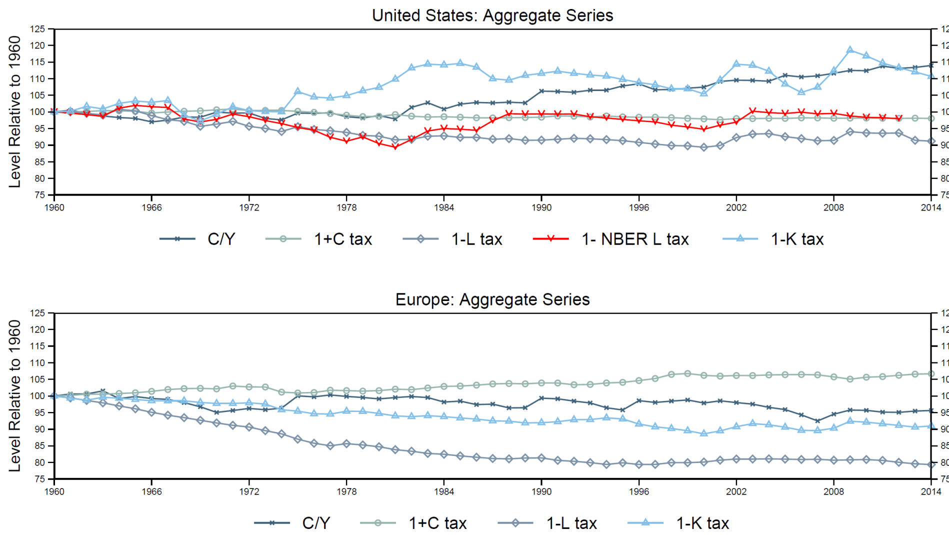

Figure 3: Empirical macroeconomic series for Europe (bottom panel) and the US (top panel).[16]

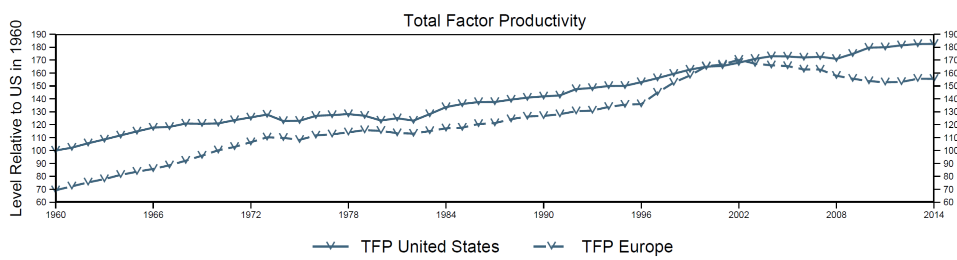

Figure 4: Total factor productivity in Europe and the US.[17]

3.2 Regression Analysis of Labor Margins

Table 2 shows results from running a panel regression with all countries in our sample, where the left-hand side variable is, alternatively, $d\ln(e_t)$, $d\ln(h_t)$, and $d\ln(H_t)$. The regressands are the contemporaneous growth rates of return-adjusted taxes (see Table 1 for definition). For each left-hand side variable this regression is run with and without a business cycle control: the growth rate of output per population, $d\ln(Y_t)$.

[16] Notes: data on total work hours are from the Conference Board's Total Economy Database, employment is from the OECD, population data are from the UN, tax data from McDaniel (2007), and output and consumption from the Penn Word Tables.

[17] Notes: data are from the Penn World tables.

Consumption taxes are insignificant, labor taxes have the correct sign throughout (higher τ^l puts downward pressure on labor market variables) and are significant on net, and investment taxes are not significant.

Finally, note that capital taxes are contemporaneously, positively, and significantly associated with e and H, but not with h. This implies that the association of H with capital taxes occurs via the association of e with capital taxes. We show later that this puzzling contemporaneous positive relationship between capital taxes and e and H (i.e. above averge capital taxes being associated with above average employment and total hours growth) arises in our model as an ex-post outcome of forward looking employment demand and can be interpreted—in line with intuition—as expected increases in capital taxes putting downward pressure on employment demand (we elaborate on this relationship later). To the best of our knowledge, this relationship between employment and capital taxes is a new stylized fact, which our model traces back to a novel interaction between these taxes and employment adjustment costs.

Table 2: Panel Regression of Labor Market Variables[18]

Variable	$d\ln(e_t)$	$d\ln(e_t)$	$d\ln(h_t)$	$d\ln(h_t)$	$d\ln(H_t)$	$d\ln(H_t)$
$d\ln(1+\tau_t^c)$	0.02	-0.33	0.08	0.01	0.10	-0.32
	(0.61)	(0.34)	(0.13)	(0.08)	(0.71)	(0.37)
$d\ln(1-\tau_t^l)$	0.22^{**}	0.16^{**}	0.07^{*}	0.05	0.29^{***}	0.21^{***}
	(0.09)	(0.07)	(0.03)	(0.03)	(0.07)	(0.06)
$d\ln(1-\tau_t^k)$	-0.18^{**}	-0.14^{**}	-0.05	-0.04	-0.23^{***}	-0.17^{***}
	(0.07)	(0.06)	(0.04)	(0.03)	(0.06)	(0.04)
$d\ln(1+\tau_t^i)$	0.01	0.59	-0.11	0.00	-0.10	0.59
	(1.09)	(0.53)	(0.22)	(0.11)	(1.29)	(0.62)
$d\ln(Y_t)$		0.29^{***}		0.06^{***}		0.35^{***}
		(0.04)		(0.01)		(0.04)
Country fix. eff.	yes	yes	yes	yes	yes	yes
Obs.	648	648	648	648	648	648

4 Theory

Our model begins as a full-fledged general equilibrium labor search model. This

[18]Notes: total work hours are from the Conference Board's Total Economy Database, employment is from the OECD, population data are from the UN, output is from the Penn World Tables, and tax data are from McDaniel (2007). τ^i is the investment tax.

approach allows for a disciplined and well-grounded theoretical justification for the way in which household-side employment attainment costs and firm-side employment adjustment costs are featured in our model. *However, the baseline specification of our model is purged from search frictions. This means that in our baseline DLM model—that is, the model from which all results presented in this paper stem—all markets are competitive, including the labor market.*

The aggregate population consists of a unit mass, and a household (*not social*) planner solves the household's optimization problem. In contrast to related literature, the economy's population is entirely selfish, atomistic, and autonomous. "Autonomous" in this paper means that each ("atomistic") household member has the power to renege on the household planner's solution if it is not incentive compatible. The resources of all economic agents that are in the household are pooled.

We assume that the household owns the economy's final-goods producing firm, and, without loss of generality, that the firm owns the economy's capital stock. Households can purchase corporate bonds issued by firms. Corporate bonds and debt mature one period after being issued. Therefore, within any period the inflow of new bonds and debt is equivalent to the total stock of bonds and debt. The inclusion of debt guarantees that firms are able to pay any incurred adjustment costs, which, as we show, ultimately link capital taxes to employment.

Mathematical details regarding all of the following can be found in the Appendix. Moving forward, all non-price variables are normalized by the aggregate population. Moreover, all price variables are normalized by the price of consumption.

4.1 The Household

As we begin from a labor search theory framework, from the household's point of view employment evolves as follows:

$$e_t = (1 - \rho)\, e_{t-1} + F\left(\chi_t\right) p_t s_t. \tag{1}$$

Above e_t denotes employment, ρ is the exogenous job destruction probability, and s_t is the endogenous mass of job searchers. $F(\chi_t)\, p_t$ is the household's *effective job finding probability.* $p_t \in [0,1]$ is exogenous, and χ_t is household-controlled search effort. $F' \geq 0$, $F'' \leq 0$, $F(0) = 0$, and $F_t \to 1$ as $\chi_t \to \infty$.[19] These diminishing returns to search effort are justified both theoretically and empirically (see, for instance, Pissarides, 2000, and Chirinko, 1984). All told, equation (1) says that period-t employment is equal to the sum of all individuals who were employed last period whose jobs were not destroyed, $(1-\rho)e_{t-1}$, and the mass of successful contemporaneous searchers, $F(\chi_t)\, p_t s_t$.[20] *This equation is a constraint in the household's problem.*

In line with canonical labor search theory we assume that *in equilibrium* all individuals participate in the labor market. Therefore, in equilibrium the mass of contemporary searchers is equal to the sum of all individuals who did not find a job in the previous period, $1 - e_{t-1}$, and the mass of all individuals whose jobs were destroyed at the end of the previous period, ρe_{t-1}. As such, in period t the mass of job searchers is

$$s_t = (1 - e_{t-1}) + \rho e_{t-1}. \tag{2}$$

Given the timing of the model in each period t there are three employment states. These states are: (1.) newly employed workers (those who flow into employment in period t, $F(\chi_t)\, p_t s_t$), (2.) "old" employed workers (those whose jobs were not destroyed at the end of the previous period, $(1-\rho)e_{t-1}$), and (3.) searchers who did not find jobs in this same period $(1 - F(\chi_t))p_t s_t$—*nonemployed individuals.*

The household's lifetime utility $\mathbf{U}_t$ is equal to the infinite sum of the weighted sum of the instantaneous utility of individuals in each employment state. As such,

$$\mathbf{U}_t \equiv \mathbb{E}_t \sum_{s=t}^{\infty} \beta^{s-t} \left\{ \begin{array}{c} e_s^{old} \overbrace{\left[u(C_s^{e,old}) - G(h_s^{old})\right]}^{\equiv v_s^{e,O}} + \; e_s^{new} \overbrace{\left[u(C_s^{e,new}) - G(h_s^{new}) - D(\chi_t)\right]}^{\equiv v_s^{e,N}} \\ + (1 - e_s) \overbrace{\left[u(C_s^{n}) - D(\chi_t)\right]}^{\equiv v_s^{n}} \end{array} \right\}.$$

[19] These assumptions guarantee that the effective job finding probability is never greater than 1, as should be the case.

[20] We follow the timing convention in Arseneau and Chugh (20120).

Above, β is the exogenous subjective discount factor, e_s^{old} denotes old employed individuals, e_s^{new} denotes new employed individuals, and $1 - e_s$ is the mass of period-s unsuccessful searchers (*nonemployed individuals*). $v_s^{e,old}$, $v_s^{e,new}$, and v_s^n are, respectively, the instantaneous utilities of each of these individuals, and $C_s^{e,old}$, $C_s^{e,new}$, and C_s^n denote the consumption these individuals.[21] We assume that these consumptions are, respectively, a fraction $\kappa_s^{e,old}$, $\kappa_s^{e,new}$, and $1 - \kappa_s^{e,old} - \kappa_s^{e,new}$ of aggregate consumption C_s. Also, h_s^{old} is hours worked per old employed individual and h_s^{new} is hours worked per newly employed individual. Finally, u is utility from consumption ($u' > 0$ and $u'' < 0$), G is disutility from work hours ($G' > 0$ and $G'' > 0$), and D is disutility from search effort ($D' > 0$, $D'' > 0$, and $D_t \to \infty$ as $\chi \to \infty$, where these last two assumptions are consistent with the assumptions on F).

Note that in the equation for $\mathbf{U}_t$ there is just "one" search effort, χ. This is because all searchers put in that search effort when they search, but some of these searchers end up employed while other fail to obtain a job. Yet, both of these agents start off as searchers, so they both suffer the same disutility from search.

As noted earlier, the economy's population is assumed to be atomistic, autonomous, and selfish. Therefore the household planner faces a series of *incentive compatibility (participation) constraints*. First, $v_t^{e,old} \geq v_t^{e,new}$. Second, $v_t^{e,new} \geq v_t^n$. Third, $v_t^n \geq \bar{v}_t$, where $\bar{v}_t$ denotes the outside option of individuals from reneging on the household planner's decision and leaving the household. Jointly, these constraints guarantee that individuals will accept the household planner's proposed solution and pool their resources within the household.

The household's *budget constraint* is

$$\begin{aligned}(1+\tau_t^c)\,C_t + (b_t - b_{t-1}) \leq &\left(1-\tau_t^l\right) w_t(h_t^{old}e_t^{old} + h_t^{new}e_t^{new}) \\ &+UB \cdot s_t + V_t + \left(1-\tau_t^k\right) r_{t-1}b_{t-1} + T_t. \qquad (3)\end{aligned}$$

[21] The instantaneous utility of individuals in old employment does not include disutility from search effort since they do not search in the current period. In contrast, both newly employed individuals and unsuccesful searchers expend contemporaneous search effort, which of course is the same in equilibrium.

Above, τ_t^c is the consumption tax, b_t denotes period-t bonds, τ_t^l is the labor tax, w_t is the real wage, UB denotes unemployment benefits, which are paid to every individual who searches in a period and is unsuccessful in finding a job, V_t denotes net-of-(capital)-tax dividends paid by the firm to the household (recall that the household owns the firm), τ_t^k is the capital tax, r_t is the period-t real interest rate, and T_t denotes government transfers. The household takes all taxes, prices, the unemployment benefit, dividends, and transfers as given.

The household planner's choice variables are the following. C_t, $\kappa_t^{e,old}$, $\kappa_t^{e,new}$, κ_t^n, h_t^{old}, h_t^{new}, e_t, s_t, χ_t, and b_t. Of course, given that $e_t^{old} = (1-\rho)\, e_{t-1}$, then knowing s_t and e_t is sufficient to know the distribution of the entire population across employment states.

In what follows, for brevity, we focus on first order conditions relevant for the labor market, only. In addition, we present the household's optimality conditions for the *baseline version of our model, which is purged from search frictions* (optimality conditions from the full-fledged search model are in the Appendix). In particular, our purging assumes: $p_t = 1$ in all periods t, $\rho = 1$, and $UB = 0$. *These assumptions are broadly in line with those used in Arseneau and Chugh (2012) when the authors show how to collapse their general equilibrium labor search model to a standard real business cycle (RBC) model.* Given these assumptions equation (1) collapses to $e_t = F(\chi_t)$.

As shown in the Appendix, in equilibrium $h_t^{new} = h_t^{old} = h_t$, which is intuitive. As also shown in the Appendix, as a result of the incentive compatibility constraints, the planner's optimal choice of $\kappa_t^{e,old}$ and $\kappa_t^{e,new}$ implies that in equilibrium in each period t the instantaneous utility of individuals in each employment state is equalized. Therefore, in equilibrium individuals are indifferent between being employed or nonemployed, *so there is no involuntary unemployment.* This is actually the case regardless of the presence of search frictions, and that is why to make this clear we refer to unsuccessful searchers as "*nonemployed*" instead of "*unemployed*."

The remaining relevant optimality conditions are as follows. For aggregate consumption: $u'(\kappa_t^{e,new} C_t)\kappa_t^{e,new} = (1+\tau_t^c)\,\lambda_t$. This is entirely standard in tax-inclusive frameworks save for the presence of $\kappa_t^{e,new}$ that nonetheless does not affect the intuition behind this equation: the time-t effective (tax-inclusive) marginal utility of consumption is equal to the marginal value of real wealth, λ_t. For hours worked per worker

$$G_t' = \lambda_t \left(1 - \tau_t^l\right) w_t e_t, \tag{4}$$

meaning that the marginal cost of hours worked per worker equals its marginal benefit. Also, combining the optimality conditions for χ_t and e_t implies that

$$D_t' = \lambda_t \left(1 - \tau_t^l\right) w_t h_t \cdot F_t'. \tag{5}$$

Given our purging of labor search components, in our baseline DLM specification choosing χ_t is the same as choosing e_t. As such, equation (5) is the household's effective employment supply equation, which means that the marginal cost of employment (the right-hand side of this equation, which is χ-dependent) is equal to its marginal benefit (the equation's left-hand side, which is also χ-dependent).

4.2 The Firm

Aggregate output Y_t is generated by the production function $Y_t = Y\left(Z_t, K_t, H_t\right)$. Here, Z_t is exogenous total factor productivity and K_t denotes capital. In line with standard CLM literature we assume that Y_t is linear in Z_t and increasing and concave in K_t and H_t. Of course, $H_t \equiv h_t \cdot e_t$.

The firm's objective function, net-of-(capital)-tax dividends, is given by

$$\mathbb{E}_t \sum_{s=t}^{\infty} \Xi_{s|t} \underbrace{\left\{ \begin{array}{c} \overbrace{\left(1-\tau_s^k\right) \left[\begin{array}{c} Y\left(Z_t, K_t, h_t e_t\right) - w_s h_s e_s - I_s \\ -r_{s-1} d_{s-1} - \Lambda\left(Z_s\right) \cdot \left(\Phi v_s + \Omega(v_s/v_{s-1}, v_s w_s)\right) \end{array} \right]}^{\equiv \bar{V}_s} \\ + \left(d_s - d_{s-1}\right) \end{array} \right\}}_{\equiv V_s}. \tag{6}$$

Above, I_s is investment, d denotes debt, Φ is the exogenous flow cost of posting vacancies v_s. Ω is a standard adjustment cost function that is increasing and convex in the ratio v_s/v_{s-1} and also increasing in $v_s w_s$. The product $v_s w_s$ captures in a reduced form way the intuition that hiring costs can reflect expenditures on a human resources department, and therefore are a fraction of the wage bill. Ω is equal to zero whenever v_s equals v_{s-1}, which, in particular, is the case in steady state (the broader relevance of adjustment costs for labor markets is emphasized by Cooper and Willis, 2004, Caballero and Engel, 2004, Cooper and Willis, 2008, and Mumtaz and Zanetti, 2014, among others.)[22]

Turning to $\Lambda(Z_t)$, following, for instance, Pissarides (2000), we assume that the firm's costs of posting vacancies are *potentially* a function of aggregate productivity. However, we do not make any assumption on whether, if productivity is indeed related to vacancy posting costs, higher productivity makes it more costly or less costly for firms to post vacancies. Instead, as discussed below, we arrive at a conclusion regarding the potential relationship between productivity and vacancy posting via empirical analysis.

The firm faces two constraints. First, a standard equation of motion for the capital stock, $K_{t+1} = I_t + (1-\delta) K_t$, where δ is the capital depreciation rate. Second, its perceived evolution of employment, $e_t = (1-\rho) e_{t-1} + q_t v_t$, where q_t is the job filling probability, which the firm takes as given. In words, this equation says that the firm's contemporaneous stock of employed individuals is equal to the sum of all of the previous period's workers who did not lose their job, $(1-\rho) e_{t-1}$, and all newly formed employment relationships, which are equal to the fraction of all vacancies posted that are filled in a period, $q_t v_t$.

The firm's choice variables are K_{t+1} (i.e., I_t), d_t, h_t, e_t, and v_t. For brevity, as we did for the household *we present the firm's optimality conditions for the baseline ver-*

[22] Of course, the change in the firm's debt position is not taxed, and, intuitively, we assume that $V_t \geq 0\ \forall t$. Moreover, we do not include investment taxes since, per the evidence in Table 1 they do not have an impact on labor market variables and, furthermore, in our DLM model, in line with CLM models, investment taxes do not have a theoretical impact on labor market variables either.

sion of our model, which, as noted earlier, is purged from search frictions (optimality conditions from the full-fledged search model are in the Appendix). In particular, as relevant for the firm, these purging assumptions are $q_t = 1$ in all periods t, $\rho = 1$, and $\Phi = 0$ (these assumptions are broadly in line with Arseneau and Chugh, 2012, when the authors show how to collapse their general equilibrium labor search model to a standard RBC model). In this environment the firm's equation of motion for employment collapses to $e_t = v_t$, so the firm's choice of vacancies is one and the same with its choice of employment.

We continue to focus on the labor market. The first order condition for h_t implies that

$$Y_{h_t} = w_t e_t, \tag{7}$$

which of course means that the marginal product of hours worked per worker is equal to its marginal cost and, therefore, that the wage is competitive. The first order condition for employment, which, recall, given our purging assumptions is one and the same with the first order condition for vacancies, is

$$-\Lambda\left(Z_t\right)\frac{\partial\Omega_t}{\partial e_t} = \mathbb{E}_t\Xi_{t+1|t}\frac{1-\tau_{t+1}^k}{1-\tau_t^k}\Lambda\left(Z_{t+1}\right)\frac{\partial\Omega_{t+1}}{\partial e_t}. \tag{8}$$

This means that whenever the firm is adjusting employment, employment demand is forward looking, as in standard models of labor demand with adjustment costs (see, for instance, Sargent, 1979).[23] Of note, the derivation of equation (8) uses the fact that from equation (7) $Y_{h,t}h_t = w_t h_t e_t$, which given the fact that $Y_{h_t}h_t$ equals $Y_{e_t}e_t$ implies, *as a result*, that $Y_{e,t}e_t = w_t h_t e_t$.

Equation (8) means that firms find it optimal to equate the post-tax marginal cost of changing employment today to the post-tax (discounted) marginal cost of changing employment tomorrow. Another way to interpret this equation is that *firms optimally decide on employment adjustment in order to smooth adjustment costs over time (and,*

[23] In periods in which the firm does not adjust employment demand, adjustment costs are zero and equation (8) implies that employment demand is pinned down by the following optimality condition: $Y_{e_t} = w_t h_t$.

more specifically, smooth the consumption value of net-of-(capital)-tax dividends for the household). As an example, suppose that at time t an expected increase in next period's capital tax rate τ_{t+1}^k lowers the ratio $\frac{1-\tau_{t+1}^k}{1-\tau_t^k}$. To restore equation (8) the firm will raise $\frac{\partial \Omega_t}{\partial e_t}$, which will require raising expected employment.

While employment adjustment costs are natural to include in a model built to rationalize cross-country differences in labor markets, note as well that the relationship between employment and capital taxes implied by such costs is a feature of the data that was captured by the regression results presented in Table 2. We elaborate on these points shortly.

4.3 Closing the Model

Throughout the remainder of the paper we henceforth focus exclusively on the baseline ("purged") version of our model. In particular, recall that this purging involves assuming the following: ρ, p_t, and q_t are equal to 1 in all periods, and UB and Φ are equal to zero in all periods. To close the model we assume that government consumption is zero, so that $T_t = \tau_t^c C_t + \tau_t^l w_t h_t e_t + \tau_t^k \left(r_{t-1} b_{t-1} + \bar{V}_t\right)$. This implies that the aggregate resource constraint is given by $Y_t = C_t + I_t + \Lambda\left(Z_t\right)\Omega\left(e_t/e_{t-1}, e_t w_t\right)$ whenever e_t is not equal to e_{t-1}, and $Y_t = C_t + I_t$ whenever the firm does not adjust employment. *The model's equilibrium is discussed in the Appendix.*

5 Operationalizing the Theory

Recall once more that throughout the remainder of the paper we focus exclusively on the "purged" version of our model.

Following the literature most related to our paper, we evaluate our model's performance by using the "business cycle accounting" approach.[24] For our purposes, this involves the following. Suppose that a variable X_t is a function of the vector of vari-

[24] Key references are, for example, Prescott (2004) and Chari, Kehoe, and McGrattan (2007) among others.

ables and parameters $\mathbf{\Psi}_t$ such that $X_t = X(\mathbf{\Psi}_t)$. The model's performance regarding this variable is evaluated by taking the equation $X_t = X(\mathbf{\Psi}_t)$ and feeding into it empirical data for $\mathbf{\Psi}_t$, which results in a theory-implied prediction for the behavior of X_t. Assessing the model's fit then involves comparing this theory-implied prediction for the behavior of X_t with its empirical behavior.

Of course, our model's equilibrium condition for h_t (equation (9)) is static, so it is straightforward to test this condition using business cycle accounting. That said, because employment demand (equation (8)) is dynamic, then so is equilibrium employment. Therefore, to be conceptually in line with business cycle accounting, as we elaborate on further below, we will assess the fit of our model's dynamic equilibrium employment equation from an ex-post vantage point. Beyond the usefulness of this approach for being in line with business cycle accounting, *this approach is also critical to shed light on the positive empirical contemporaneous relationship between employment and capital taxes that we highlighted earlier in Table 2.*

5.1 Functional Forms

In line with related literature we assume a standard constant returns to scale production function $Y_t = Z_t K_t^{\alpha} (h_t e_t)^{1-\alpha}$ where $\alpha \in (0, 1)$ and therefore $Y_{h_t} h_t = (1-\alpha) Y_t$ and $Y_{e_t} e_t = (1-\alpha) Y_t$. Turning to employment demand, we assume that $\Lambda(Z_t) = Z_t^{\zeta}$, where, as discussed earlier, ζ will be estimated and its value could, in principle, be less than zero, greater than zero, or equal to zero. We also assume the following cost function: $\Omega_t = \psi \mathbb{I}_t (e_t/e_{t-1})^{\phi} e_t w_t$, where $\psi > 0$, $\phi > 1$, and $\mathbb{I}_t$ equals zero if e_t equals e_{t-1} and $\left(\frac{\beta\phi}{1+\phi}\right)^{t-1}$ otherwise. As such, $\mathbb{I}_t$ guarantees that adjustment costs are zero whenever the firm is not adjusting vacancies (which, in particular, is the case in steady state), the fact that when adjusting employment $\mathbb{I}_t$ equals $\left(\frac{\beta\phi}{1+\phi}\right)^{t-1}$ is a technical assumption that guarantees that the growth rate of employment is zero in steady state (see the Appendix for further details).

Turning to the household, following the assumptions in Shimer (2009) as applicable to the present context we assume $G(h_t) = \gamma \frac{\varepsilon}{1+\varepsilon} (h_t)^{\frac{1+\varepsilon}{\varepsilon}}$, where: γ and ε are parameters that are strictly greater than zero. As such, in our DLM model ε is the Frisch elasticity of the supply of hours worked per *worker*. Also following Shimer (2009), let $u(\cdot) = \ln(\cdot)$. For expositional tractability we assume $F(\chi_t) = \varphi\chi_t^{\sigma}$, where $\sigma \in (0,1)$ and $\varphi > 0$ (parameters are assumed to be in line with only infinite search effort being sufficient to approach a value of F_t equal to 1, even though our assumed functional form for F does not asymptote at 1), and also $D_t = \varrho\chi_t^{\theta}$, where $\theta > 1$ and $\varrho > 0$.

5.2 DLM Testable Implications

5.2.1 Hours Worked per Worker

As shown in the Appendix, combining the demand and supply of hours worked per worker implies the following equilibrium condition, which is one of two testable implications that our model yields about the labor market:[25]

$$h_t = \left[(1-\alpha)\cdot\gamma^{-1}\left(1-\tau_t^l\right)\cdot\left(1+\tau_t^c\right)^{-1} C_t/Y_t\right]^{\frac{\varepsilon}{1+\varepsilon}}. \quad (9)$$

Above, ε is the elasticity of hours worked per *worker* with respect to the wage. Intuitively, increases in labor taxes chip away at the value of the extra hour of work, increases in consumption taxes raise the price of consumption, and therefore increase the opportunity cost of consumption in terms of leisure, and a higher consumption-output ratio reduces the marginal value (in terms of consumption) of an additional hour of work.

To generate our model's predictions of hours worked per worker, we proceed as follows. First, we run a panel of the regression corresponding to equation (9) after taking logarithms. Coefficients are constrained as implied by the theory, and we arrive at a single cross-country estimate of $\frac{\varepsilon}{1+\varepsilon}$, so for our purposes the preference parameter ε is the same across countries. Then, for each country in our sample, we feed country-

[25] Given our functional form assumptions first order condition for aggregate consumption is

$$C_t^{-1} = \left(1+\tau_t^c\right)\lambda_t.$$

Therefore, the optimal values of the κ variables are irrelevant for our analysis.

specific empirical time series data on consumption, consumption taxes, output, and labor taxes, into the right-hand side of equation (9) that, given our estimate of $\frac{\varepsilon}{1+\varepsilon}$, yield our DLM model's *country-specific* predictions for hours worked per worker. Since our interest is in long run trends, in line with related literature, such as Shimer (2009), the value of $\frac{1-\alpha}{\gamma}$ is chosen so that the average of predicted hours worked per worker match the average of their empirical counterpart *on a country-by-country basis.*

5.2.2 Employment

Turning to employment, with our assumed functional forms and taking logs equation (8) yields the following "forward looking" condition for employment demand:[26]

$$d\ln e_t = \frac{1+\phi}{\phi} d\ln e_{t+1} + \frac{1}{\phi}\begin{bmatrix} d\ln w_{t+1} + \zeta d\ln Z_{t+1} \\ -d\ln \lambda_{t+1} + d\ln\left(1-\tau^k_{t+1}\right) \end{bmatrix} \tag{10}$$

(see the Appendix for details). Therefore, *from the vantage point of the firm's period-t decision making* equation (10) conveys the following optimal firm-side actions. Higher $d\ln w_{t+1}$, higher $d\ln e_{t+1}$, and *lower* $d\ln \lambda_{t+1}$ are associated with higher future output, given which the firm anticipates an expansion in future employment. In order to smooth adjustment costs, the firm frontloads some of this employment expansion, which puts upward pressure on $d\ln e_t$. For concreteness assume that $\zeta < 0$. As such, higher $d\ln Z_{t+1}$ means lower adjustment costs in the future. In smoothing these costs the firm postpones some contemporaneous adjustment, which puts downward pressure on $d\ln e_t$. Finally, higher capital taxes mean that future net-of-capital-tax dividends will be lower, given which the firm wants to adjust the least possible amount today in order to get as much net-of-tax-dividends today and, therefore, before the increase in capital taxes. This puts downward pressure on $d\ln e_t$.

It follows that the right-hand side of equation (10) reflects *causal* factors affecting the firm's contemporaneous demand. However, solving this equation for $d\ln e_{t+1}$

[26] As noted earlier, we will focus on from an ex-post perspective later in order to make business cycle accounting feasible, which is why here for simplicity we drop expectation operators.

and lagging the equation one period gives us an ex-post perspective that, therefore, reflects *outcomes* (and *not contemporaneous causality*) that should be observed *given* the firm's decisions in the earlier period (*this approach is critical to shed light on the positive empirical contemporaneous relationship between employment and capital taxes that we highlighted earlier)*:

$$d\ln e_{t+1} = \frac{\phi}{1+\phi} d\ln e_t - \frac{1}{1+\phi}\left[\begin{array}{c} d\ln w_{t+1} + \zeta d\ln Z_{t+1} \\ -d\ln \lambda_{t+1} + d\ln\left(1-\tau_{t+1}^{k}\right) \end{array}\right]. \tag{11}$$

Combining the dynamic equation for employment demand with a dynamic version of employment supply (see the Appendix for details) yields our model's second testable implication, which is the following dynamic equation for equilibrium employment:[27]

$$\begin{aligned} d\ln e_t = & \frac{\phi}{\phi + \left(\frac{\sigma}{\theta}\right)^{-1}} d\ln e_{t-1} \\ & + \frac{1}{\phi + \left(\frac{\sigma}{\theta}\right)^{-1}}\left[\begin{array}{c} \left(1+\frac{\varepsilon}{1+\varepsilon}\right) d\ln\left(1-\tau_t^{l}\right) - \frac{\varepsilon}{1+\varepsilon} d\ln\left(1+\tau_t^{c}\right) \\ -\frac{\varepsilon}{1+\varepsilon} d\ln\left(C_t/Y_t\right) - d\ln\left(1-\tau_t^{k}\right) - \zeta d\ln Z_t \end{array}\right]. \end{aligned} \tag{12}$$

Intuitively, this is an autoregressive moving average process with exogenous variables (ARMAX) for equilibrium employment—clearly, this equilibrium process is nonexplosive in employment. In this equation the variables scaled by coefficients that include ε trace back to the supply of hours worked per worker, of which employment supply is a function of. The terms that involve ε, which are $\left(1+\frac{\varepsilon}{1+\varepsilon}\right) d\ln\left(1-\tau_t^{l}\right)$, $\frac{\varepsilon}{1+\varepsilon} d\ln\left(1+\tau_t^{c}\right)$, and $\frac{\varepsilon}{1+\varepsilon} d\ln\left(C_t/Y_t\right)$, also trace back to the supply of hours worked per worker, and their impact on equilibrium employment is akin to their impact on equilibrium h. In addition, the presence of σ/θ traces back to employment supply and reflects the relative degree of diminishing returns to search.[28]

[27] Moreover, the household's stochastic discount factor is

$$\Xi_{s|t} \equiv \beta^{s-t} C_t \cdot C_s^{-1}\left(1+\tau_t^{c}\right)\left(1+\tau_s^{c}\right),$$

where $s \geq t$, which means that higher consumption as well as higher consumption taxes (or, taken together, higher consumption expenditures) at time t lower the marginal value of consumption in that period.

[28] It is straightforward to show that in steady state equilibrium employment is tax-wise only a

To operationalize equation (12) via business cycle accounting we first estimate its parameters. To be internally consistent, the regressors $\left(1+\frac{\varepsilon}{1+\varepsilon}\right)d\ln\left(1-\tau_t^l\right)$, $\frac{\varepsilon}{1+\varepsilon}d\ln\left(1+\tau_t^c\right)$, and $\frac{\varepsilon}{1+\varepsilon}d\ln\left(C_t/Y_t\right)$ are generated using the estimate of ε obtained from from running the regression corresponding to equation (9). As such, our (constrained, as implied by the theory) regression of equation (12) yields estimates of $\frac{\phi}{\phi+\frac{\theta}{\sigma}}$, $\frac{1}{\phi+\frac{\theta}{\sigma}}$, and $\frac{\zeta}{\phi+\frac{\theta}{\sigma}}$.

Recall that in estimating equation (9) we run a panel with all countries in our sample since with that equation we are ultimately estimating ε, which is a preference parameter and therefore should not be assumed to be different across countries. However, in estimating equation (12) we are guided by the fact that there are well-known differences between the relative flexibility of European versus U.S. labor markets (see, for instance, Llosa et al., 2014). For example, consider the OECD's indicators of employment protection legislation (indices that go from 0, which implies least employment restrictions, to 6, which implies most employment restrictions)[29]. In our European sample, the average index for: protection of permanent workers against individual and collective dismissal is 2.47; the average protection of permanent workers against individual dismissal is 2.16; specific requirements for collective dismissal is 3.24; and regulation on temporary forms of employment is 1.91. In contrast, in the United States these figures are, respectively: 1.17 (over 50 percent lower than in Europe); 0.49 (nearly 80 percent lower than in Europe); 2.88 (over 10 percent lower than in Europe); and 0.33 (over 80 percent lower than in Europe).

Importantly, note that in equation (12) all parameters to be estimated can be interpreted as reflecting, in a reduced form way, economic factors related to labor market rigidities. Indeed, a relatively higher value of ϕ means that it is more costly for firms to adjust employment, a relatively higher value of θ/σ means that relative returns to search decrease at a faster rate, and, assuming for concreteness that ζ is negative, a lower ζ means that higher productivity lessens employment adjustment costs by a relatively lower amount. In line with the evidence on labor market rigidities,

function of labor taxes (decreasing) and consumption taxes (decreasing).

[29] https://www.oecd.org/employment/emp/oecdindicatorsofemploymentprotection.htm

it follows that there is no reason to expect that these parameters would be the same in Europe as in the United States. Thus, in estimating equation (12) we run a panel for Europe and a separate regression for the United States.

Given the estimated parameter values from running the regressions to estimate equation (12), we generate our model-predicted level employment series for *each country* in our sample as follows. Let x_i denote empirical values for country i's variable x, x_i denote predicted values for country i of variable x, and $\hat{\boldsymbol{\beta}}$ denote the applicable vector of parameter estimates from running the regressions to estimate equation (12). First, we generate our model-predicted employment growth rate for country i between the first growth rate that we can predict conditional on our data's starting point (period $t-1$ for the purposes of what follows immediately below before ending this section) using the following equation:

$$d\ln\left(e_{i,t}\right) = \hat{\boldsymbol{\beta}}' \times \left[\begin{array}{c} d\ln\left(e_{i,t-1}\right), d\ln\left(1-\tau^{l}_{i,t}\right), d\ln\left(1+\tau^{c}_{i,t}\right), \\ d\ln\left(C_{i,t}/Y\right), d\ln\left(1-\tau^{k}_{i,t}\right), d\ln\left(Z_{i,t}\right) \end{array} \right].$$

Then, we predict growth rates using as lagged growth rates the model's own predicted growth rates. In other words, the model's prediction of $d\ln\left(e_{i,t+1}\right)$ uses $d\ln\left(e_{i,t}\right)$. *Therefore, except for the first lagged growth rate, all other lagged growth rates used to get our model-generated predictions are fully and entirely endogenous.*

Second, with our model-generated growth rates in hand, we then use the first empirical level of employment in period t along with the model-predicted growth rate between period t and period $t+1$ to arrive at the model's first predicted *level* value of employment. We generate the remaining level values of employment by using the previous period's *predicted* employment levels. Akin to our model's hours worked per worker predictions, the (level) employment series predicted by our model is rescaled to have the same mean as the empirical employment series on a country-by-country basis.[30]

[30] We obtain our DLM model's predicted equilibrium employment series using its dynamic version since in our data no two adjacent employment figures are the same. In other words, in taking our model to the data the implication is that employment adjustment costs were paid in every period.

5.3 CLM Model H

We operationalize a representative version of the CLM model, in particular, the one used in Shimer (2009), in order to compare results from this model regarding H to the results from our DLM model. This version of the CLM model yields tax-inclusive results that are representative of related literature: a successful prediction of hours worked per population in Europe and highly counterfactual results for the United States.

In the CLM model the production function is the same as in our DLM model, and the household's instantaneous utility is $\ln(C_t) - \varepsilon(1+\varepsilon)^{-1}(H_t)^{\frac{\varepsilon}{1+\varepsilon}}$, so in this case ε is the Frisch elasticity of the supply of hours worked per *population* (in contrast to the DLM model, where ε is the Frisch elasticity of the supply of hours worked per *worker*). Of course, all taxes we consider in our DLM model remain the same in the CLM model, and in the CLM model the household's budget constraint is the same as in our DLM model.

All told, as shown in the Appendix, the following is the single equilibrium labor market condition that arises in the CLM model:

$$H_t = \left[(1-\alpha)\cdot\gamma^{-1}\left(1-\tau_t^l\right)\cdot\left(1+\tau_t^c\right)^{-1} C_t/Y_t\right]^{\frac{\varepsilon}{1+\varepsilon}}. \tag{13}$$

(recall that the CLM model does not distinguish between the different margins of labor). Importantly, note that the right-hand side of equations (9) and (13) are the same (therefore, the intuition behind equation (13) is entirely analogous to the intuition behind equation (9)). Of note, this means that per our DLM model the CLM model's equation for equilibrium H is, in fact, an equation for equilibrium h.

In abstract terms it is straightforward to show that our DLM model's equilibrium condition for hours worked per worker is

$$h_t = G^{-1}\left(\lambda_t\left(1-\tau_t^l\right)Y_{h,t}h_t\right)$$

and the CLM model's equilibrium condition for hours worked per population is

$$H_t = G^{-1}\left(\lambda_t\left(1-\tau_t^l\right)Y_{H,t}H_t\right).$$

With perfect substitutability of e and h in production, then $Y_{h,t}h_t = Y_{H,t}H_t$ in the equations above. Therefore, the fact that our DLM model's equation for equilibrium h is the same as that of the CLM model for equilibrium H is not functional form dependent.

To operationalize equation (13) we take logarithms as in the case of the hours per worker equation from our DLM model and run a constrained panel regression to estimate the CLM model's value of ε. Then, we generate the CLM model-generated predicted H_t using the same methodology used to generate DLM-model predicted h as discussed earlier. *Results from this operationalization are those shown in Figure 1 in the paper's Introduction.*

6 Results

Recall that H is the only endogenous labor market variable predicted by the CLM model, and that the H predicted by our DLM model is built from the bottom up by first predicting h and e separately. Per the operationalization description in Section 5, our results obtain from predicting the CLM model's $H_{i,t}$ for each country i in our sample, and predicting our model's $h_{i,t}$ and $e_{i,t}$ for each country in our sample and then constructing $H_{i,t}$ by multiplying these two. Model-generated results for Europe are the simple average across the model-predicted $H_{i,t}$ of European countries in our sample.

In what follows, we first show results from the regressions detailed earlier and highlight the implications of parameter estimates (Section 6.1). Then, we summarize model performance from a quantitative perspective across countries and on an individual basis (Section 6.2). In addition, we address model performance from the trend and contour perspective (Section 6.3). Finally, we focus on the implications of our model for international risk sharing (Section 6.4).

6.1 Parameter Estimates

Table 3 shows results from running, in the fashion discussed earlier, constrained panel regressions of equations (9) and (13) in rows 1 and 2, respectively. All parameter estimates are statistically significant and of the correct sign. For our DLM model's h the implied estimate of ε is 1.44 (in this case the Frisch elasticity of the supply of hours worked per *worker*), and for the CLM model's H the implied estimate of ε is 2.84 (in this case the Frisch elasticity of hours worked per population).

Table 3: Estimates of Labor Elasticities[31]

Variable	$\ln(C_t/Y_t)$	$\ln(1+\tau_t^c)$	$\ln(1-\tau_t^l)$	Country fix. eff.	Obs.
$\ln(h_t)$	-0.59***	-0.59***	0.59***	yes	660
	(0.02)	(0.02)	(0.02)		
$\ln(H_t)$	-0.74***	-0.74***	-0.74***	yes	660
	(0.03)	(0.03)	(0.03)		

Table 4 shows results from running the constrained regression of equation (12) in panel form for Europe (first row) and individually for the United States (second row). All parameter estimates are statistically significant. Moreover, the implied value of $\phi + \theta/\sigma$ is 11.11 in Europe and 4.16 in the United States. Give these values: (1.) the implied value ϕ is 5.56 in Europe and 1.78 in the United States, which means that the elasticity of employment adjustment costs with respect to the relative size of adjustment is over twice as high in Europe compared to the United States; and (2.) the implied value of θ/σ in Europe is 5.55 and 2.38 in the United States, which means that search returns decrease at a rate over twice as high in Europe compared to the United States. Finally, the implied value of ζ is -0.44 in Europe and -0.79 in the United States. Since ζ is negative, this means that when productivity is higher, employment adjustment costs are lower—intuitively, this can capture in a reduced form way that higher productivity can offset expansionary structural changes in the firm that must take place in order to accommodate more workers. Moreover, the fact

[31]Notes: total work hours are from the Conference Board's Total Economy Database, employment is from the OECD, and population data are from the UN. Construction of model results use tax data from McDaniel (2007), and consumption and output data are from the Penn Word Tables.

that the value of ζ in the United States is less than its value in Europe implies that higher productivity decreases employment adjustment costs by less in Europe than the United States.

All told, we speculated that parameters in our model's dynamic expression for equilibrium employment reflect underlying structural factors related to labor market rigidities. Results shown in Table 4 are in line with this. Indeed, the implied rigidities from our results are consistent with these rigidities being substantially greater in Europe compared to the United States, which is in line with empirical evidence that studies these rigidities explicitly. *Taken together, these results lend substantial validity to our model.*

Table 4: Estimates of Employment Equation $d\ln(e_t)$ regressand[32]

	$d\ln$ of variable:							
Region	e_{t-1}	TFP_t	$\frac{C_t}{Y_t}$	$1+\tau_t^c$	$d\ln 1-\tau_t^k$	$d\ln 1+\tau_t^l$	Country fix. eff.	Obs.
Europe	0.50***	0.04**	-0.09**	-0.09**	-0.09**	0.09**	yes	583
	(0.05)	(0.02)	(0.03)	(0.03)	(0.03)	(0.03)		
US	0.43**	0.19**	-0.24**	-0.24**	-0.24**	0.24**	—	53
	(0.19)	(0.08)	(0.09)	(0.09)	(0.09)	(0.09)		

6.2 Cross-Country Quantitative Performance

A key issue related to our research is understanding the extent to which our model does relatively better or worse at predicting hours worked per *population* across countries compared to the CLM model. To get at this assessment at the individual country level, define for each country i in our sample the sum of squared deviations measure

$$SSD_i \equiv \sum_t \left(d\ln H_{i,t}^{DLM} - d\ln H_{i,t}\right)^2 \cdot \left[\sum_t \left(d\ln H_{i,t}^{CLM} - d\ln H_{i,t}\right)^2\right]^{-1}$$

[32]Notes: total work hours are from the Conference Board's Total Economy Database, employment is from the OECD, and population data are from the UN. Construction of model results use tax data from McDaniel (2007), and output, consumption and productivity data from the Penn Word Tables.

and the sum of absolute deviations measure

$$SAD_i \equiv \sum_t \left| d\ln H_{i,t}^{DLM} - d\ln H_{i,t} \right| \cdot \left[\sum_t \left| d\ln H_{i,t}^{CLM} - d\ln H_{i,t} \right| \right]^{-1},$$

where $d\ln H_{i,t}$ is the growth rate of empirical H and $d\ln H_{i,t}^{j}$ is model-predicted H by model $j \in \{CLM, DLM\}$. Then, for country i consider the numbers $100 \cdot (1 - SSD_i) \equiv \widetilde{SSD}_i$ and $100 \cdot (1 - SAD_i) \equiv \widetilde{SAD}_i$. This means that for $z_i \in \{\widetilde{SSD}_i, \widetilde{SAD}_i\}$ numbers $z_i > 0$ denote that our model does z_i percent better than the CLM model at predicting the growth rate of H, while numbers $z_i < 0$ denote that our model does z_i percent worse than the CLM model at predicting the growth rate of H. Of course, $z_i = 0$ implies that both models do equally well.

Table 5 shows $\widetilde{SSD}_i$ and $\widetilde{SAD}_i$ for all countries in our sample. On the basis of these metrics, we conclude that, compared to the CLM framework, our DLM model is an important step forward in understanding and predicting the behavior of hours worked per population. Results imply that on average our model does better than the CLM model by between 12 and 20 percent, with notable improvements of up to 43 percent for the United Kingdom and 31 percent for the United States. The only country for which model performance is about the same is France.

Table 5: Comparison of CLM and DLM model performance[33]

(in %)	Austria	Belgium	Finland	France	Germany	Italy
$\widetilde{SSD}_i$	16.26	32.64	23.64	0.63	25.26	11.91
$\widetilde{SAD}_i$	4.21	26.5	7.89	−2.43	11.50	9.03
(in %)	Netherlands	Spain	Sweden	Switzerland	UK	US
$\widetilde{SSD}_i$	18.24	11.43	10.72	12.64	43.11	31.49
$\widetilde{SAD}_i$	10.62	7.83	8.19	7.69	28.15	22.7

[33] Notes: total work hours are from the Conference Board's Total Economy Database, employment is from the OECD, and population data are from the UN. Construction of model results use tax data from McDaniel (2007), and output, consumption and productivity data from the Penn Word Tables.

6.3 Trend and Contour Analysis

Table 6 shows notation used for the purposes of presenting results in what follows. For our model, Figure 5 shows results for h, and Figure 6 shows results for e. Finally, Figure 7 shows results for H stemming from both our DLM model and the CLM model.

Table 6: Notation for DLM Model Generated Variables

Notation	Meaning
h (e) *DLM*	Prediction per equation 9 (12)
H *DLM*	Product of h DLM and e DLM
h (e) *DLM* C/Y *fix*	Prediction per equation 9 (12) holding C/Y fixed
h (e) *DLM cons tax fix*	Prediction per equation 9 (12) holding τ_t^c fixed
h (e) *DLM lab tax fix*	Prediction per equation 9 (12) holding τ_t^l fixed
e *DLM cap tax fix*	Prediction per equation 9 holding τ_t^k fixed
e *DLM TFP fix*	Prediction per equation 9 holding TFP fixed

Figure 5 shows that our model tracks the behavior of h in both Europe and the United States very well. The same is true for e as shown in Figure 6. In each of these figures, counterfactuals ("fix") series are generated from the model, holding constant (one at a time) the ingredients that go into predictions of each variable. These graphs reveal the most important forces associated with the behavior of each variable. Per Figure 5, in the United States, increases in C/Y and τ^l (recall Figure 3) have put downward pressure on h. Quantitatively, changes in the consumption-output ratio are associated with hours worked per worker being about 8 percent lower in 2014 compared to what they would have been otherwise; and changes in labor taxes are associated with hours worked per worker being about 6 percent lower in 2014 compared to what they would have been otherwise. In Europe the most important variable associated with the behavior of h is τ^l, with results implying that absent the substantial secular increase in τ^l (recall Figure 3) h would have been flat. In fact, the secular increase in labor taxes in Europe are associated with hours worked per worker being about 14 percent lower in 2014 compared to what they would have been otherwise.

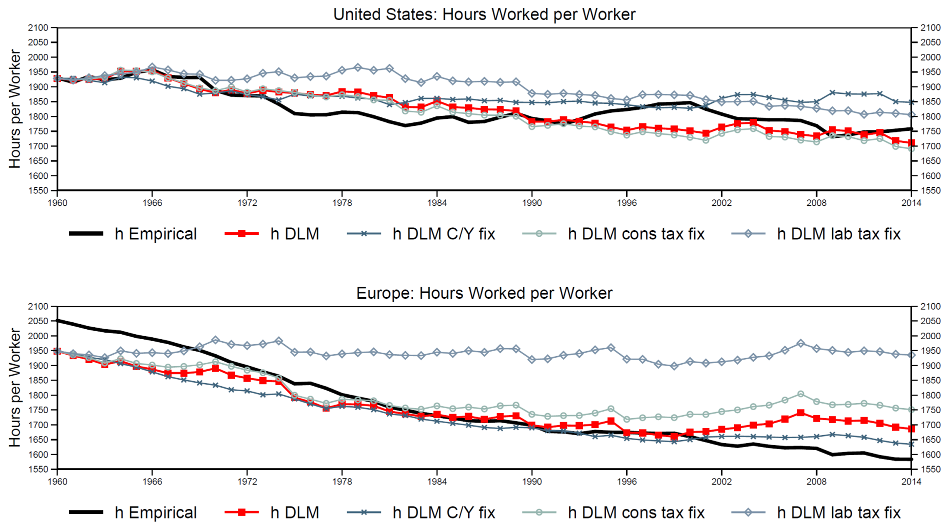

Figure 5: Empirical hours worked per population and DLM model predictions for Europe (bottom panel) and the US (top panel).[34]

Per Figure 6, in the United States gains in TFP (recall Figure 4) are the most important factor associated with gains in employment, absent which e would have been flat. Equivalently, changes in TFP are associated with employment in 2014 being about 18 percent higher compared to what it would have been otherwise. Taxes and C/Y play a secondary role, and mostly matter for the contour of e. That said, increases in C/Y and τ^l, and decreases in τ^k (recall Figure 3) jointly put downward pressure on e. (Recall that per our model's equation for equilibrium employment, the contemporaneous relationship between capital taxes and employment is not causal, but instead an observed outcome of forward-looking employment demand from earlier periods given which, and in line with intuition, capital taxes put downward pressure on employment demand.) In quantitative terms, changes in the consumption-output ratio, labor taxes, and capital taxes are each associated with employment in 2014 being lower by 6 percent compared to what it would have been otherwise. For Europe, the message regarding e from Figure 6 is quite stark: flat e is associated with the secular increase in τ^l offsetting gains in TFP that would have otherwise been

[34]Notes: total work hours are from the Conference Board's Total Economy Database, employment is from the OECD, and population data are from the UN. Construction of model results use tax data from McDaniel (2007), and output and consumption data from the Penn Word Tables.

associated with gains in e.

A comparison of the results for employment in Europe and the United States with regards to changes in TFP shows why our DLM model is useful for understanding international differences in the drivers of long run labor market trends. Recall from Figure 4 , that TFP increased on net throughout the sample period in Europe. It would thus have been natural to expect, in light of the results for the United States, that our model would predict increasing employment in Europe as well, in contrast to empirical employment being flat. However, the bottom panel of Figure 6 shows that the changes in European labor taxes over the period were such that employment in Europe is over 5 percent lower in 2014 compared to what it would have been otherwise, and changes in TFP were such that employment in Europe in 2014 is about 6 percent higher compared to what it would have been otherwise. This results in the DLM model tracking the behavior of employment in Europe very well.

Bringing the two margins of labor together, Figure 7 shows our model's predictions for hours worked per population. Also shown are empirical H and, for reference, the CLM model's predictions as well (already shown in Figure 1). For Europe, both models perform successfully and fairly similarly. For the United States our model matches the shallow V-shape of empirical H, while as discussed earlier the CLM model predicts a counterfactual secular decrease in H.

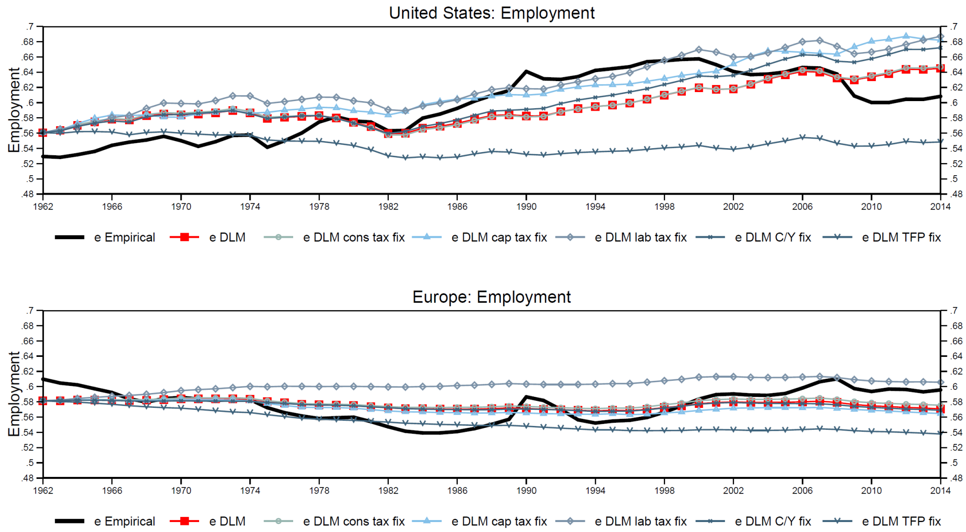

Figure 6: Empirical employment-population ratio and DLM model predictions for Europe (bottom panel) and the US (top panel).[35]

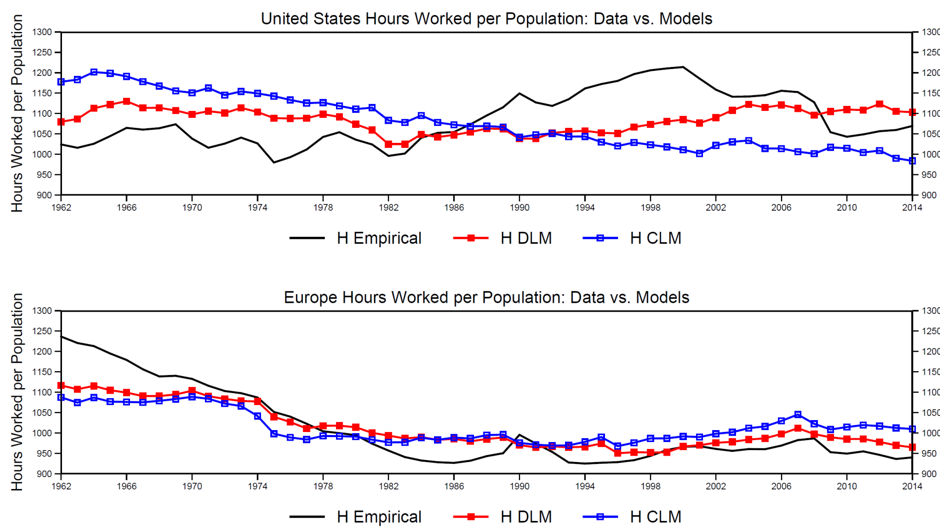

Figure 7 Empirical hours worked per population and DLM and CLM model predictions for Europe (bottom panel) and the US (top panel).[36]

As highlighted earlier in the data section, the labor-tax series from McDaniel

[35]Notes: employment is from the OECD, and population data are from the United Nations. Construction of model results use tax data from McDaniel (2007), and output, consumption and productivity data from the Penn Word Tables.

[36]Notes: total work hours are from the Conference Board's Total Economy Database, employment is from the OECD, and population data are from the United Nations. Construction of model results use tax data from McDaniel (2007), and output, consumption and productivity data from the Penn Word Tables.

(2007), which are *average* taxes, do not reflect, contour wise, the Reagan tax reforms (1981 through 1986), which in contrast the NBER labor-tax series, which are *average marginal* taxes, indeed do reflect. Recall as well that both series have broadly the same trend, and that amid the Reagan tax reforms the McDaniel series imply rising labor taxes—which of course is driven by an increase in the tax base—while the NBER series imply decreasing taxes, as should be the case.

To assess the impact of these differences, Figure 8 shows results for e and H for the United States from operationalizing our DLM model with the NBER taxes, as well as results from the CLM model for H. Regarding e, comparing Figures 6 and 8 shows that our DLM model gets much better at the hump in employment starting in the early 1980s. This makes sense amid decreasing labor taxes as implied by the NBER tax series. Comparing Figures 7 and 8, the same is true for H. *The endpoints of e and H predictions are much tighter as well.* In addition, the CLM model's predictions continue to yield counterfactual decreasing H.

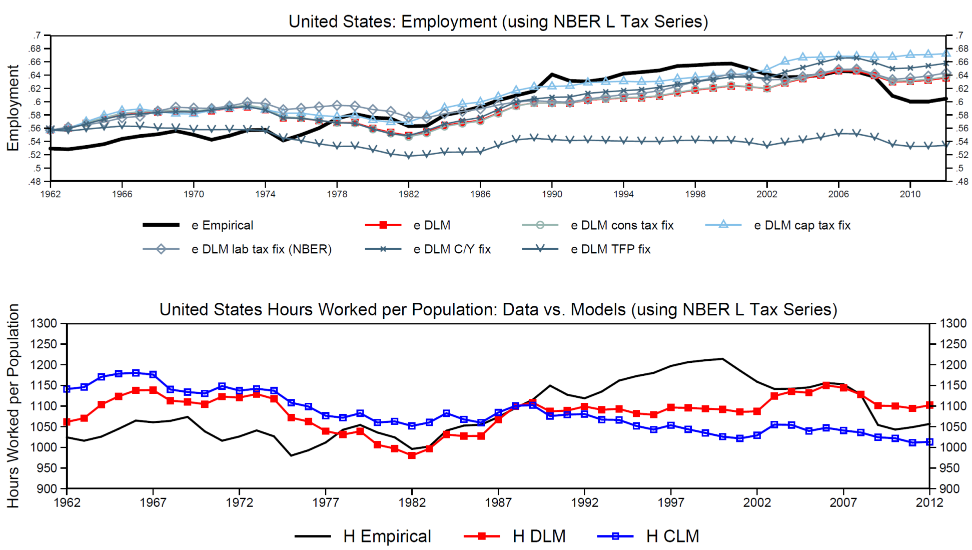

Figure 8: Results for the United States using NBER labor taxes instead of McDaniel (2007) labor taxes.[37]

In the Appendix we elaborate in further detail on the results described immedi-

[37]Notes: total work hours are from the Conference Board's Total Economy Database, employment is from the OECD, and population data are from the United Nations. Construction of model results use labor-tax data from the NBER, and output, consumption and productivity data from the Penn Word Tables.

ately above regarding the NBER taxes. We also show that an extension of our DLM model that accounted for differences in trends in employment by gender would for all purposes close the small remaining employment-hump gap between model and data that remains in the 1990s.

6.4 Implications for International Risk Sharing

While the analysis so far focused on trying to understand international differences in long run labor market outcomes, our model also has implications for tracking the evolution of long run international risk sharing. These implications can serve as additional tests of the validity of our DLM model relative to the CLM model. We address all of these issues below.

As shown in the Appendix, using a simple multi-country extension of our model that features a complete set of state contingent assets, the following *baseline* (tax-inclusive) consumption risk sharing condition must hold for any pair of countries i and j:

$$\frac{C_{i,t}\left(1+\tau^{c}_{i,t}\right)}{C_{i,t+1}\left(1+\tau^{c}_{i,t+1}\right)}\left(1-\tau^{k}_{i,t+1}\right)=\frac{C_{j,t}\left(1+\tau^{c}_{j,t}\right)}{C_{j,t+1}\left(1+\tau^{c}_{j,t+1}\right)}\left(1-\tau^{k}_{j,t+1}\right). \qquad (14)$$

This equation is the same that Epstein et al. (2016) derive using a tax-inclusive open economy version of the CLM model. Epstein et al. (2016) show that in the presence of capital and consumption taxes, the usual consumption risk sharing condition (which states that given perfect risk sharing the growth rates of consumption will be equalized between any pair of countries i and j) must be adjusted to account for these taxes. Intuitively, equation (14) says that cross-country differences in relative prices caused by different consumption taxes make it optimal to diverge from perfect equality of consumption growth across countries, while capital taxes, by penalizing the financial instruments used for risk sharing, further cause divergence of consumption growth rates across countries.

Following Epstein et al. (2016), within our model we define a "all tax-inclusive risk-sharing wedge," $\Gamma^{A,i,j}_{t}$, which captures the extent to which the risk sharing condition above fails at any given point in time between any two countries i and j:

$$\Gamma_t^{A,ij} \equiv \frac{\frac{C_{i,t}\left(1+\tau_{i,t}^c\right)}{C_{i,t+1}\left(1+\tau_{i,t+1}^c\right)}\left(1-\tau_{i,t+1}^k\right)}{\frac{C_{j,t}\left(1+\tau_{j,t}^c\right)}{C_{j,t+1}\left(1+\tau_{j,t+1}^c\right)}\left(1-\tau_{j,t+1}^k\right)}. \tag{15}$$

"Failures" are captured by instances in which $\Gamma_t^{A,ij} \neq 1$, and therefore $\Gamma_t^{A,ij} = 1$ implies perfect risk sharing. Solving for $C_t\left(1+\tau_t^c\right)$ in our model's equilibrium condition for h (equation (9)), it immediately follows that equation (15) can be restated as

$$\Gamma_t^{h,DLM,ij} = \frac{\frac{\left(1-\tau_{i,t}^l\right)(1-\alpha)\frac{Y_{i,t}}{h_{i,t}}}{\gamma h_{i,t}^{\frac{1}{\varepsilon}}}\left[\frac{\left(1-\tau_{i,t+1}^l\right)(1-\alpha)\frac{Y_{i,t+1}}{h_{i,t+1}}}{\gamma h_{i,t+1}^{\frac{1}{\varepsilon}}}\right]^{-1}\left(1-\tau_{i,t+1}^k\right)}{\frac{\left(1-\tau_{j,t}^l\right)(1-\alpha)\frac{Y_{j,t}}{h_{j,t}}}{\gamma h_{j,t}^{\frac{1}{\varepsilon}}}\left[\frac{\left(1-\tau_{j,t+1}^l\right)(1-\alpha)\frac{Y_{j,t+1}}{h_{j,t+1}}}{\gamma h_{j,t+1}^{\frac{1}{\varepsilon}}}\right]^{-1}\left(1-\tau_{j,t+1}^k\right)}, \tag{16}$$

(which we refer to as Wedge DLM) with, in particular, hours worked per worker h on the left-hand side. Similarly, solving for $C_t\left(1+\tau_t^c\right)$ from the CLM model's equilibrium condition for H, equation (13), the CLM model's counterpart to this wedge, $\Gamma_t^{CLM,ij}$, has, instead of h, hours worked per population H on the left-hand side:

$$\Gamma_t^{H,CLM,ij} = \frac{\frac{\left(1-\tau_{i,t}^l\right)(1-\alpha)\frac{Y_{i,t}}{H_{i,t}}}{\gamma H_{i,t}^{\frac{1}{\varepsilon}}}\left[\frac{\left(1-\tau_{i,t+1}^l\right)(1-\alpha)\frac{Y_{i,t+1}}{H_{i,t+1}}}{\gamma H_{i,t+1}^{\frac{1}{\varepsilon}}}\right]^{-1}\left(1-\tau_{i,t+1}^k\right)}{\frac{\left(1-\tau_{j,t}^l\right)(1-\alpha)\frac{Y_{j,t}}{h_{j,t}}}{\gamma H_{j,t}^{\frac{1}{\varepsilon}}}\left[\frac{\left(1-\tau_{j,t+1}^l\right)(1-\alpha)\frac{Y_{j,t+1}}{H_{j,t+1}}}{\gamma H_{j,t+1}^{\frac{1}{\varepsilon}}}\right]^{-1}\left(1-\tau_{j,t+1}^k\right)}, \tag{17}$$

(which we refer to as Wedge CLM).

The connection between (15), and (16) or (17), arises from the requirement that households optimally (and jointly) choose labor and consumption, as well as the requirement of labor market equilibrium within each country. Intuitively, to the extent that perfect risk sharing calls for the (tax-scaled) growth of the marginal utility of consumption to be equated across countries (i.e., $\Gamma_t^{A,ij} = 1$), it also requires equating across countries the growth in disutility required to finance a unit of additional consumption growth (i.e., $\Gamma_t^{h,DLM,ij} = 1$ and $\Gamma_t^{H,CLM,ij} = 1$ in the DLM and CLM models respectively).

The development so far allows us to implement the following open economy test of our DLM model's validity relative to the CLM model, which is in similar spirit to the exercise whose results we showed in Table 5. If our DLM model fits the data better than the CLM model, then $\Gamma_t^{h,DLM,ij}$ should track $\Gamma_t^{C,ij}$ better than $\Gamma_t^{H,CLM,ij}$, and vice versa. We implement this test by following Epstein et al. (2016) in letting the benchmark country j be the United States and calculating the risk sharing wedges (baseline, Wedge DLM and Wedge CLM) relative to the United States for each country i in our sample.

Figure 9 provides a visual summary of the results from this exercise by plotting the cross-country simple average of all three wedges. Both Wedge DLM and Wedge CLM track the baseline wedge closely. Moreover, in line with results from Epstein et al. (2016) all three wedges show trend improvements in risk sharing (driven by the evolution of capital taxes), which is reflected by the wedges converging to unity.

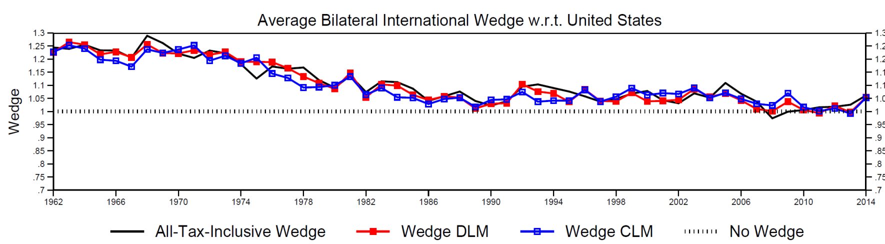

Figure 9: International risk sharing wedges.[38]

To assess quantitatively whether the DLM model fits the data better than the CLM model, which as noted earlier is consistent with $\Gamma_t^{h,DLM,ij}$ tracking $\Gamma_t^{A,ij}$ better than $\Gamma_t^{H,CLM,ij}$ we do the following. We compute, analogous to our exercise in Section 6.2,

$$SSD_{iUS}^{IBC} \equiv \sum_t \left(\Gamma_t^{h,DLM,iUS} - \Gamma_t^{A,iUS}\right)^2 \cdot \left[\sum_t \left(\Gamma_t^{H,CLM,iUS} - \Gamma_t^{A,iUS}\right)^2\right]^{-1}$$

[38]Notes: total work hours are from the Conference Board's Total Economy Database, employment is from the OECD, and population data are from the United Nations. Construction of model results use tax data from McDaniel (2007), and output, consumption and productivity data from the Penn Word Tables.

and

$$SAD_{iUS}^{IBC} \equiv \sum_t \left|\Gamma_t^{h,DLM,iUS} - \Gamma_t^{A,iUS}\right| \cdot \left[\sum_t \left|\Gamma_t^{H,CLM,iUS} - \Gamma_t^{A,iUS}\right|\right]^{-1}$$

(where IBC is our acronym for "international business cycle"). Then, also analogously to our exercise in Section 6.2, to assess the validity of the DLM model relative to the CLM model, we compute $100 \cdot (1 - SSD_{iUS}^{IBC}) \equiv \widetilde{SSD}_{iUS}^{IBC}$ and $100 \cdot (1 - SAD_{iUS}^{IBC}) \equiv \widetilde{SAD}_{iUS}^{IBC}$.

The results, shown in Table 7 below, imply that on average, compared to Wedge CLM, Wedge DLM tracks the baseline wedge 36% better per the SSD_{iUS}^{IBC} metric and 22% better per the SAD_{iUS}^{IBC} metric. In other words, applying the two models to measure risk sharing through labor market variables also delivers the message that our DLM model is able to track long run labor-market developments better compared to the CLM model.

Table 7: CLM and DLM in terms of international risk sharing[39]

(in %)	Austria	Belgium	Finland	France	Germany	Italy
$\widetilde{SSD}_{iUS}^{IBC}$	34.83	26.81	27.41	23.51	37.00	49.36
$\widetilde{SAD}_{iUS}^{IBC}$	22.07	18.40	11.00	11.28	20.26	29.64
(in %)	Netherlands	Spain	Sweden	Switzerland	UK	US
$\widetilde{SSD}_{iUS}^{IBC}$	31.70	62.01	29.74	28.14	48.32	–
$\widetilde{SAD}_{iUS}^{IBC}$	18.97	42.82	20.43	26.65	27.55	–

7 Conclusions

The contemporary, canonical, macroeconomic model serves as a common framework that can get at the fundamental driving forces associated with the behavior of H. Using this common framework led to notable progress in accounting for the short run (business cycle) behavior of H, but there has been relatively less progress in

[39]Notes: total work hours are from the Conference Board's Total Economy Database, employment is from the OECD, and population data are from the UN. Construction of model results use tax data from McDaniel (2007), and output, consumption and productivity data from the Penn Word Tables.

accounting for the long run (trend) behavior of H. A promising solution to this issue was extending the model to include taxes. However, a tax-inclusive version of the model can explain the behavior of H in Europe, but leads to stark counterfactual results for the US. We refer to this as the "U.S. tax puzzle." This puzzle is endemic to related literature, and in this paper we seek to understand what drives it and whether it can be resolved.

We show that a novel yet tractable extension of the canonical macroeconomic model that disentangles the extensive and intensive margins of labor hours can, accounting for taxes, successfully explain the long run behavior of H in *both* Europe and the US. The model that we propose has two key features that distinguish it from the canonical model. First, the presence of employment-attainment costs on the household side. Second, the presence of firm-side employment adjustment costs.

In explaining the data, the model shows that taxes and, in particular, capital taxes, impact the two margins of labor quite differently. Therefore, if these margins are not disentangled the full impact of taxes on H does not come through. This disentanglement also suggests that adjustment costs are an avenue via which a clear positive correlation between employment and productivity can emerge, and this relationship is also critical for explaining the data. This is something that was not highlighted by earlier related literature.

The model has implications regarding the relative rigidity of labor markets and also regarding international risk sharing, both of which are in line with the data and therefore validate the model's structure. In addition, the model can explain a new stylized fact that we document and, in principle, is perplexing. In the data, at yearly frequency there is a positive contemporaneous relationship between capital taxes and employment. However, the model suggests that this is indeed what should be observed, but it is the result of forward-looking employment demand decisions. Importantly, as far as these demand decisions go, the model shows that the relationship between employment and capital taxes is indeed intuitive: higher capital taxes put downward pressure on employment.

Beyond addressing the U.S. tax puzzle, the extent to which our model is successful suggests that it can also be used as a laboratory for studying the trend behavior of H as related to a host of other factors. These factors include, but are not limited to: a slowdown in world output growth; changes in demographics that are currently critical for advanced economies; and policy issues such as labor-market reforms, pension reforms, and tax reforms.

8 Acknowledgements

The authors are thankful for very useful feedback provided during presentations at Bates College, Bentley University, the Boston Fed, Florida International University, IHEID, the Swiss Society of Economics and Statistics Meetings, Texas State University, Trinity University, University of Colorado, Boulder, University of Houston, University of Miami, University of Nottingham, University of Texas at Dallas, University of Utah, University of Zurich, and also for comments from David Arseneau, Michael Elsby, Julia Cajal, Mary Corcoran, Chris Foote, Jim Hines, Miguel Iraola, Brian Jacob, Taylor Jaworski, Miles Kimball, Omar Licandro, Rick Mansfield, Alessandro Peri, Celine Poilly, Alessandro Ruggieri, Manuel Santos, Matthew Shapiro, Joel Slemrod, Jeff Smith, Cédric Tille, and Ian Wright. All errors are our own.

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