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The Leisure Gains from International Trade

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ABSTRACT: The average number of hours worked has been declining in many countries. This can be explained if workers have preferences with income effects outweighing substitution effects. Then, an optimal response to rising income is to reduce labor supply to enjoy more leisure. In this paper, I develop a novel structural link between trade and aggregate labor supply. Using a multi-country Ricardian trade model, I show that reducing trade barriers leads to fewer hours worked while being compatible with an increase in welfare. In addition, I derive an hours-to-trade elasticity and estimate it by exploiting exogenous income variation generated by aggregate trade. On average, I quantify that the rise in trade openness between 1950 and 2014 explains 7 percent of the total decline in hours per worker in high-income countries.

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1 Introduction

The annual number of hours worked has fallen in many countries. To explain this decline, several studies have focused on the role of government policies, e.g., labor and consumption taxes (Prescott, 2004; Ohanian et al., 2008). However, recent studies suggests that policies alone have limited explanatory power, and that income differences could explain up to 77% of cross-country differences in hours worked (Bick et al., 2019c). Income differences are only relevant if households have preferences with income effects outweighing substitution effects (Boppart and Krusell, 2020). If this is the case, they would optimally react to an increase in income by choosing to forego some additional consumption to enjoy leisure time. These preferences could explain why households in richer countries work fewer hours (Bick et al., 2018), as well as the long-run decline in hours within countries (Rogerson, 2006; Ramey and Francis, 2009). However, identifying these preferences is challenging because it requires exogenous income variation at the country level.

In this paper, I assess the response of hours worked to income by exploiting exogenous income variation generated by trade. International trade has risen rapidly since 1950 with the fall of trade barriers and increased regional trade agreements (Baldwin, 2016). Many developing and developed countries have become more integrated into the global economy. Among economists, there is a broad consensus that trade boosts income through access to cheaper consumption goods, inputs and technology (Frankel and Romer, 1999; Donaldson, 2015). Therefore, using trade as an exogenous shifter of income, I study the causal impact of both trade and income on hours worked. I ask three main questions: First, do income effects dominate substitution effects? If so, how many hours of leisure is trade generating? Finally, how much of the observed decline in hours worked since 1950 is due to the increase in trade openness?

To answer these questions, I build a multicountry Ricardian trade model that establishes a theoretical link between trade and hours worked (henceforth hours). I extend the canonical Eaton and Kortum (2002) model with a representative household that supplies labor elastically. As in Boppart and Krusell (2020), households' preferences allow for different income and substitution effects with respect to changes in real wages. If income effects are larger than substitution effects, households would reduce their labor supply and enjoy more leisure as a response to a rise in income. The production and trade side follow the standard Eaton and Kortum model. When countries reduce trade barriers, they can import goods at a lower cost. This leads to an increase in real income through lower prices for domestic consumption. Households optimally react to the boost in real income generated by trade in the same way they would to any exogenous increase in income.

I derive a structural link between labor supply and trade. The number of hours worked in any country can be expressed as a function of its domestic trade share (one minus the import penetration ratio) and its average level of efficiency.[1] If the elasticity of hours to real wages is negative (i.e., income effects dominate substitution effects), households would, *ceteris paribus*, work fewer hours in countries that are more open to trade. I derive an elasticity of hours-to-trade, which is a function

[1] For clarification: a lower domestic trade share implies a more open economy.

of two sufficient statistics: the elasticity of hours to real wages (uncompensated or Marshallian elasticity), and the trade elasticity.

With aims at estimating the hours-to-trade elasticity and provide evidence of dominating income effects, I turn on to an empirical framework. I regress hours per worker on the domestic trade share using a panel of 46 developing and developed countries over the span 1950–1995. In addition, I estimate the impact of the domestic trade share on income. Besides having a causal interpretation, the two estimated coefficients capture general equilibrium effects. They provide a consistent mapping between my theory and empirical findings, and allow me to recover the underlying hours-to-wages and trade elasticities.

To identify the causal effects of trade on hours, I instrument the domestic trade share using Feyrer (2019)'s time-varying instrument based on geography. Between 1950 and 1995, the cost of air freight fell remarkably, generating an exogenous reduction in trade costs. Country pairs whose distance was much shorter by air than by sea benefited significantly more from this technology. Using this variation, the instrument predicts countries' trade based on geography and air transportation costs. The use of this instrument addresses endogeneity concerns regarding changes in overall productivity (which affect both hours and trade), as well as changes in domestic labor legislation and policies, such as taxation. In addition, country fixed effects control for time-invariant institutions and cultural attitudes that affect labor supply decisions.

My empirical results support the view that income effects dominate substitution effects. I estimate the elasticity of hours to real wages of -0.16, broadly in line with previously assumed values in the literature. Along which margin does aggregate labor supply adjust to income changes? I estimate the effect of trade on the intensive margin (hours per employed worker) and the extensive margin (employment rate). I find a significant effect of trade on hours worked through the intensive margin, but no significant effect on the extensive margin.

Finally, I quantify the leisure gains from trade. These are defined as the difference between the equilibrium number of hours worked with trade and in autarky. For a selection of OECD countries, I quantify that between 1950 and 2014, trade openness contributed to an additional 19 to 91 hours of leisure per worker per year. Across countries, the leisure time generated by trade represents between 2.3 and 15.1 percent of the total decline in hours per worker over this period.

The leisure gains from trade vary widely across countries. Small open economies, such as Switzerland and the Netherlands, enjoy more leisure hours from trade than economies such as the US or Japan. I measure the potential leisure loss if countries were to move from current levels of trade to autarky. I find that, for the median country in my sample, workers would find it optimal to increase their supply of hours by 10 percent (23 working days per year) to compensate for the income lost due to the complete trade shutdown.

This paper contributes to the literature on the long-run determinants of hours worked. Multiple studies estimate the response of hours worked to income for individual workers, relying on exogenous wage and wealth shocks (Ashenfelter et al., 2010; Farber, 2015; Cesarini et al., 2017; Richards, 2020, among others). See Chetty et al., 2013 for a review. In contrast, this study provides the first estimate of the uncompensated elasticity at the *aggregate* level, which eliminates external validity concerns from quasi-experimental studies by capturing the labor supply response from the whole population. Furthermore, the magnitude of this elasticity is in line with those calibrated in recent macro studies (Heathcote et al., 2014; Boppart and Krusell, 2020; Bick et al., 2018, 2021).[2]

My findings also support the view of productivity as a driver of the long-run behavior of hours worked (Rogerson, 2006). In my model, opening to trade is isomorphic to an increase in total factor productivity (TFP) in a closed economy (as in Waugh, 2010). When I exploit variation in trade openness through a geographic instrument, it can be understood as generating a random and exogenous increase in TFP across countries. This exogenous variation in TFP allows me to assess the long-run behavior of hours with respect to income across households.[3]

This paper also contributes to the vast literature on trade and labor market outcomes. A large body of research focuses on the *distributional* effects of trade along different margins of hours worked (hours per worker, unemployment rate and participation rate). For example, Autor et al. (2013), Topalova (2010), Lyon and Waugh (2019) and Kim and Vogel (2021) show that trade is associated with higher unemployment and lower participation rates following a trade liberalization. Over time, affected workers are expected to find new jobs in other sectors and/or regions over time, despite frictions slowing down this transition (Artuç et al., 2010; Dix-Carneiro and Kovak, 2017; Zi, 2019).

Unlike these studies with a local labor market focus, I abstract from distributional impacts and study the effects of trade on labor supply with an *general equilibrium* perspective. I theoretically show that the welfare gains from trade are actually larger when labor supply is elastic. My empirical results corroborate this view. I show that the adjustment of hours worked is driven by those already in employment. In addition, the non-significant effect of trade on the employment rate reveals that employment losses in sectors adversely affected by trade (e.g. manufacturing in the US after 2000) should be compensated by more job demand in other sectors.[4]

The remainder of the paper is organized as follows. Section 2 depicts some stylized facts of hours worked, trade and income. In Section 3, I present the model and derive the structural relationship between hours worked and trade. Section 4 discusses the econometric approach for estimating the main equations of the model, my identification strategy and the data. Section 5 presents the econometric results. In Section 6, I quantify the leisure and overall welfare gains from trade. Finally, Section 7 concludes.

[2] See Section 5.3 for a discussion.

[3] An alternative strand of literature studying declining hours worked is the tax-and-transfer one, where government policies create a wedge between the marginal utility of consumption and leisure, thus creating a disincentive to work (Prescott, 2004; Alesina et al., 2005; Rogerson, 2006, 2007; Ohanian et al., 2008; Rogerson and Wallenius, 2009; McDaniel, 2011; Velasquez and Vtyurina, 2019; Epstein et al., 2019). Another large body of research focuses on the heterogeneity in demographics, education, labor legislation, and behavior of population sub-groups (Aguiar and Hurst, 2007; Ragan, 2013; Bick et al., 2019a,b; Boerma and Karabarbounis, 2020; Aguiar et al., 2021).

[4] In a follow-up paper, I study how leisure gains from trade are allocated across household members, see (Depetris-Chauvin and Velasquez, 2024).

2 Motivational Facts

In this section I present some stylized facts that motivate my theoretical model. Using a cross-section of countries, I show how hours worked, trade and income correlate with each other.

Households in closed economies work more hours

I refer to hours worked as hours *effectively* worked. This definition excludes holidays, sick days and paid leave, but include all not-remunerated labor for market activities.[5] To compare countries, I begin by focusing on a *per capita* measure of hours worked. This measure can be thought as the total number of hours supplied by a representative household, without differentiating which members work and how much.[6]

I argue that trade leads to leisure gains. Then it should be that households living in countries that are more closed (open) to trade work more (fewer) hours. Figure 1a depicts a clear negative correlation between average annual hours worked per capita and the import share of each country (defined as the value of total imports divided by GDP at current prices).

Next, I analyze the correlation between hours worked and one of the main determinants of trade: distance. It is a well-known fact that trade flows between trading partners diminishes as the distance between them grows (Disdier and Head, 2008). Therefore, if we think there is a causal link between trade and hours, this link should also be present between distance and hours.

I define remoteness as the sum of the weighted distance of each country with respect to all other countries (whether they are trading partners or not), where the weight is GDP to proxy for market size. Figure 1b presents the results. A simple linear fit shows that households living in countries that are more remote —farther away from larger economies —tend to work more hours (the correlation coefficient is 0.61). The effect is clear for isolated countries such as Paraguay, Bolivia and Peru. On the other hand, the least remote countries are those in the EU.

Next, I present two other stylized facts: trade is associated with higher income, and households in higher income countries work fewer hours.

Trade is positively correlated with income

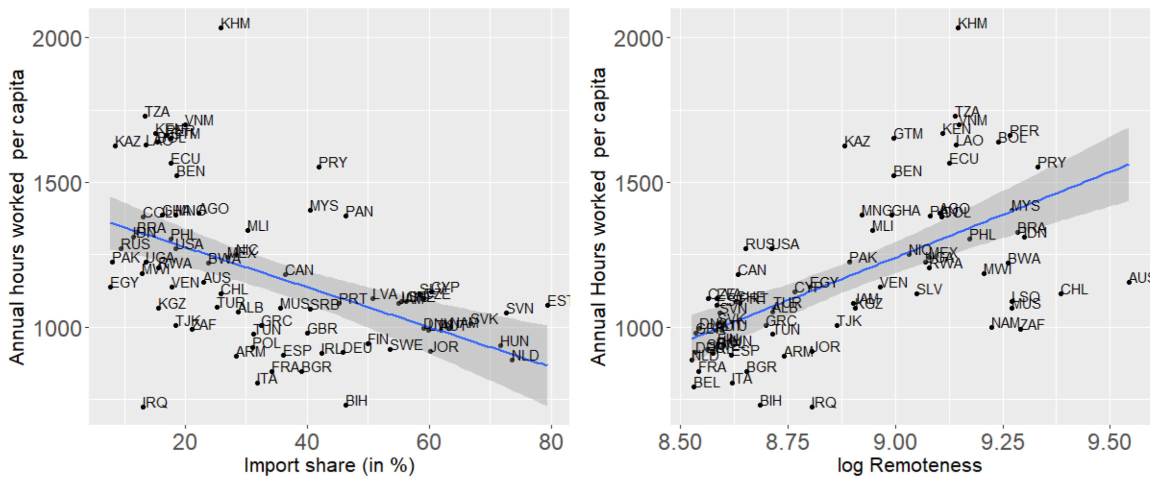
I argue that trade affects the number of hours worked through income effects. Ever since Samuelson (1939) demonstrated that international trade is Pareto improving, most economists and policymakers have promoted it as a policy to boost per capita income. There are several mechanisms through which trade increases income, such as access to cheaper inputs and consumption goods, productivity gains through technology diffusion and resource reallocation, and institutional convergence through deep trade agreements.

[5] In the data section 4.3 I provide more details on the definition of hours worked.

[6] Unlike other studies that divide total hours worked in the economy by the working age population (15-64 years old), I focus on per capita terms to capture total labor potential. I favor this definition because my data includes many developing countries where the young and old population often engage in working activities.

Figure 1: Hours, trade and distance

(a) Hours per capita and import share (b) Hours per capita and remoteness



Note: correlation in (a) is -0.51 and for (b) is 0.61. Source: Bick et al. (2018), PWT and CEPII.

A causal effect of trade on income has been well documented in the literature (see Frankel and Romer, 1999; Freund and Bolaky, 2008; Wacziarg and Welch, 2008; Feyrer, 2021, among many others). While there are some exceptions, such as Pascali (2017), most studies find a positive impact of trade on income. Figure 3a in Appendix F depicts the positive correlation between the two variables.

Hours worked and income are negatively correlated

While the positive correlation between trade and income is well known, the negative correlation between income and hours worked is less so. With recently collected data on hours worked, Bick et al. (2018) document that households in high-income countries work significantly less than those in low-income countries. In Figure 3b in Appendix F, I replicate Bick et al. (2018)'s main results plotting hours per capita and income per capita for a cross-section of countries. This figure depicts a clear negative correlation.

The negative correlation between hours worked and income can also be observed across time. For example, Ramey and Francis (2009) document that workers in the US spend significantly less time working today than than what they did a century ago. Boppart and Krusell (2020) analyze the decline in hours for several countries in the second half of the 20th century. They provide evidence that hours fell the most in countries with higher increases in TFP. In addition, they show that the steady fall in hours is not explained by a variation of demographics or the time spent in education.

Through which margin of hours do households adjust their labor supply? Long-run data shows that the decline in the number of hours worked per capita is mainly along the intensive margin (hours per worker). Figure 4a in Appendix F shows that the average number of annual hours worked divided by the total number of employed workers presents a negative trend. In contrast, the extensive margin of hours (the employment rate) is quite stable over time. Figure 4b in Appendix F shows the time series of the total number of employed workers over total population for several countries. While there is plenty of heterogeneity across countries, its mean is almost flat in the long run. In the long run, the decline in per capita hours is driven mainly by those who are employed supplying fewer hours. This differentiation is important. If trade affects hours worked through income, then its effects should be observed along the intensive margin.

3 Theory

In this section I discuss the preferences of a representative household with an elastic labor supply. Then, I include these preferences in the Eaton and Kortum (2002) model. This extended model can explain the correlations between trade, hours and income described in the previous section.

3.1 Preferences

My model features a series of open economy countries indexed by $i = 1, 2, \dots, N$. Each country is populated by a representative household with utility function

$$U_i(C_i, H_i) = \begin{cases} \dfrac{C_i^{1-\eta} - 1}{1-\eta} - \dfrac{\psi_i H_i^{1+\frac{1}{\varepsilon}}}{1+\frac{1}{\varepsilon}} & \text{if} \quad \eta \neq 1 \\ \log C_i - \dfrac{\psi_i H_i^{1+\frac{1}{\varepsilon}}}{1+\frac{1}{\varepsilon}} & \text{if} \quad \eta = 1, \end{cases} \tag{1}$$

where C_i denotes aggregate consumption of goods and H_i denotes the number of hours worked; $\eta \geq 0$ is the inverse of the intertemporal elasticity of substitution and $\varepsilon \geq 0$ is the Frisch elasticity. ψ_i is a scalar that weighs the disutility of working, and can potentially vary across countries. This formulation was first proposed by MaCurdy (1981) to evaluate the response of labor to changes in real income over time.

My theory assumes that all countries are on their balanced growth path. Despite the lack of an explicit time dimension, η is a key parameter. It allows for income and substitution effects to vary with respect to income, as discussed below. Households earn income from labor, which they use to consume. The budget constraint is

$$C_i = \frac{w_i}{P_i} H_i, \tag{2}$$

where w_i is the nominal wage and P_i is the price index of domestically consumed goods. The representative household's problem is to choose the optimal amounts of consumption and leisure time. Maximizing the utility function subject to the budget constraint yields the following combined first order condition

$$\frac{w_i}{P_i} C_i^{-\eta} = \psi_i H_i^{\frac{1}{\varepsilon}}. \tag{3}$$

By replacing the budget constraint into (3), we reach the representative household's labor supply

$$H_i = \tilde{\psi}_i \left(\frac{w_i}{P_i} \right)^{-\frac{(\eta-1)\varepsilon}{1+\varepsilon\eta}} = \tilde{\psi}_i \left(\frac{w_i}{P_i} \right)^{\rho} \qquad \textit{with} \quad \tilde{\psi}_i = \psi_i^{-\frac{\varepsilon}{1+\varepsilon\eta}}, \tag{4}$$

Labor supply is a function of the real wage, the intertemporal elasticity of substitution, the Frisch elasticity, and the constant $\tilde{\psi}$. For a simple exposition, define ρ to be the elasticity of hours worked to real wages (also referred as the uncompensated or Marshallian elasticity), which takes the form

$$\rho = -\frac{(\eta - 1)\varepsilon}{1 + \varepsilon\eta}.$$

This expression is key in my analysis as it predicts the response of labor supply to an increase in real income. Given that ε takes non-negative values, the sign of ρ entirely depends on η. There are three relevant scenarios. If $\eta > 1$, ρ will be negative and an increase in real wages will decrease the supply of hours. In other words, the income effect of a rise in real wages outweighs the substitution effect. Households prefer to use the extra income to reduce their labor supply and enjoy more leisure instead of working the same (or more) hours and enjoying higher levels of consumption.

On the contrary, if $\eta < 1$ then $\rho > 0$ and the effects are reversed. The substitution effect dominates the income effect. This means that following an increase in real wages, the representative household will take advantage of the higher wages and supply more hours to increase its consumption. The household is willing to sacrifice leisure for higher consumption.

The third case has $\eta = 1$, leading to $\rho = 0$. In this case the income and substitution effects cancel out and hours worked do not react to changes in real wages. Many macroeconomic models assume that labor supply does not react to changes in income. They model (1) with $\eta \to 1$ to get $\log(C)$ as in King et al. (1988). The main purpose of this type of modeling is to match the trend-less labor supply in US time series data.

The cross-country and time series evidence presented in Section 2 suggest that $\eta > 1$ and $\rho < 0$. As countries develop and real income rises over the long run, households prefer to enjoy more leisure at the expense of consumption. This form of modeling labor supply contrasts sharply with other ways of modeling income effects. For example, trying to rationalize the higher level of hours worked in less-developed countries, some researchers have included Stone-Geary preferences in their utility functions to include temporary income effects (Rogerson, 2006; Ohanian et al., 2008). They include $\log(C - c)$ in consumers' utility functions, where c is a constant which represents subsistence level of consumption. This mechanically creates a high labor supply in countries with low income (and consumption) levels. However, this effect disappears as C grows large, predicting trend-less hours in rich countries. In contrast, the model presented here predicts that hours worked in all countries decline at the same constant pace. That is to say that ρ is common for all countries and that the labor supply curve does not bend.[7]

[7] Boppart and Krusell (2020) recently proposed the utility function (1) as a special case of a generic family of utility

3.2 Incorporating preferences into the Eaton and Kortum model

I include preferences (1) and the budget constraint (2) into the Eaton and Kortum (2002) model. Consumption in each country is based on a basket of differentiated goods. I assume that there is a continuum of differentiated goods indexed by $u \in [0, 1]$, and households have CES preferences over these goods. The aggregate consumption function is

$$C_i = (\int_0^1 c_i(u)^{\frac{\sigma-1}{\sigma}} du)^{\frac{\sigma}{\sigma-1}},$$

where $c_i(u)$ denotes the amount consumed of each good and σ is the elasticity of substitution. I assume all consumption goods are gross substitutes, $\sigma > 1$.

Production

To produce quantity $y_i(u)$ of any good u, a firm employs linear technology in labor. Firms purchase labor hours from competitive markets and pay an hourly wage w_i, and sell their products at producer price $p_i^p(u)$. The profit maximization problem of the firm is

$$\max_{H_i(u)} p_i^p(u) z_i(u) H_i(u) - w_i H_i(u), \tag{5}$$

where the term $z_i(u)$ captures the Hicks-neutral efficiency of each firm producing variety u in country i, and it is the sole factor that varies across firms. The model assumes perfect competition in all goods and labor markets. Unit prices are given by the marginal cost of production, $\frac{w_i}{z_i(u)}$.

The productivity for each firm u in each country is drawn from a Fréchet probability distribution. This probability distribution, which is assumed to be independent across goods and countries, takes the form

$$Pr(z_i \leq z) = F_i(z) = e^{-T_i z^{-\theta}}.$$

This expression tells us the probability of drawing an efficiency unit less than or equal to an arbitrary number z. This probability is driven by two parameters. $T_i > 0$, which drives the location of the distribution, defines the degree of absolute advantage. A larger T_i increases the likelihood of drawing a higher z_i for any firm producing u. The parameter $\theta > 1$, which is assumed to be constant across countries, measures the heterogeneity in production. A higher value implies a smaller variation in efficiency levels. As shown in Eaton and Kortum (2002), a lower θ implies more comparative advantage and a stronger force encouraging trade.

Trade

All countries are open to trade. Trade between countries is subject to trade costs that are modeled as "iceberg costs", which are denoted by $d_{in} \geq 1$. d_{in} measures how many units need to be shipped

functions that is consistent with declining hours worked on a balanced growth path. In Appendix A I discuss how this utility function predicts a long-run decline in hours worked for $\rho < 0$ while being consistent with balanced growth.

from country n so that one unit arrives to country i. The model assumes $d_{in} > 1$ whenever $i \neq n$, and no costs for the consumption of domestically produced goods, $d_{ii} = 1 \quad \forall i$. In addition, I assume that there is cross-border arbitrage. This means that for any triple of countries n, k, i, $d_{in} \leq d_{ik} d_{kn}$.

The model assumes perfect competition. This means that the price of good u produced by n and offered to country i equals its marginal cost taking into account trade costs

$$p_{in}(u) = \frac{w_n d_{in}}{z_n(u)}.$$

Countries will shop around the world looking for the best deal. Eventually, the price paid by country i for good u is the lowest price across all countries (including the home country):

$$p_i(u) = \min\{p_{in}(u); n = 1, \ldots, N\}.$$

Equilibrium

With this setting in mind, now I present the equations that characterize the equilibrium. My model is characterized by the price index, the trade share and the trade balance. The derivations of these equations are shown and discussed in detail in Eaton and Kortum (2002).

Price index. P_i denotes the price index of goods available for domestic consumption. It reflects the price level of the basket of goods the representative household buys. P_i is a function of the marginal cost of production and the trade barriers of all countries around the world. The Fréchet probability distribution allows me to derive the exact price index P_i that each buyer in country i is facing as follows.

$$P_i \equiv \gamma \Phi_i^{-1/\theta} \qquad \text{and} \qquad \Phi_i \equiv \sum_{n=1}^{N} T_n \left(w_n d_{in}\right)^{-\theta}, \tag{6}$$

where $\gamma = [\Gamma(\frac{1-\sigma}{\theta} + 1)]^{\frac{1}{1-\sigma}}$ is a constant (Γ is the gamma function) and $\sigma < \theta + 1$ is imposed to make the gamma function well behaved. Notice how Φ_i, and eventually P_i, only varies across countries due to trade costs d_{in}. An increase in d_{in} raises the supplier price from n and reduces the probability that n is the lowest cost supplier, raising the price index.

Trade share. The trade share indicates the fraction of total expenditure in country i that is used to purchase goods from country n. Define X_{in} as the value of imports at c.i.f. prices of country i from country n. Given the price index (6), the probability that country n is the lowest cost supplier to i is given by the price of good n in Φ_i. The trade share π_{in} is defined as:

$$\pi_{in} \equiv \frac{X_{in}}{X_i} = \frac{T_n (w_n d_{in})^{-\theta}}{\Phi_i}, \tag{7}$$

with $\sum_{n=1}^{N} \pi_{in} = 1$.

Trade balance. The model assumes that trade is balanced. This means that the value of total imports should match the value of total exports

$$w_i H_i = \sum_{n=1}^{N} \pi_{in} w_n H_n. \tag{8}$$

The equilibrium of this economy involves a series of wages $\{w_i\}$ and hour allocations $\{H_i\}$ that are consistent with labor supply (4), the price index (6), the trade share (7), and trade balance (8). Uniqueness requires the necessary condition $\theta > -\rho$. In other words, the absolute magnitude of the elasticity of hours to wages needs to be smaller than that of the trade elasticity. It is assumed that θ is larger than one. Therefore, labor supply reacts less than one-to-one with respect to changes in real wages. See Appendix B for the proof.

3.3 Accounting for hours worked

Having derived the main equilibrium conditions for the model, I now present the structural link between the equilibrium of hours worked and trade.

First, I derive an expression for the *domestic* trade share π_{ii}, starting from the trade share (7). This expression shows expenditure on domestic production divided by total national expenditure

$$\pi_{ii} = \frac{T_i (w_i)^{-\theta}}{\sum_{n=1}^{N} T_n (w_n d_{in})^{-\theta}}. \tag{9}$$

I then link (9) to the price index (6), using the denominator (which is Φ_i). Combining both equations leads to an expression for the real wage in the domestic economy[8]

$$\frac{w_i}{P_i} = \pi_{ii}^{-1/\theta} T_i^{1/\theta}. \tag{10}$$

The real wage is a function of both the domestic trade share and the average level of efficiency. This equation shows that trade openness (i.e. a decline in π_{ii}) increases real wages. Lower trade barriers allow countries to export more and import cheaper goods. This lowers the price index and raises real wages. Similarly, the average efficiency level T_i also has a positive effect on wages mediated by trade. Note how both effects depend on the magnitude of θ.

Next, I derive the equilibrium of hours worked in the economy. Replacing real wages (10) into the labor supply (4) yields the equilibrium of hours worked at the country level:

$$H_i = \tilde{\psi}_i \pi_{ii}^{-\frac{\rho}{\theta}} T_i^{\frac{\rho}{\theta}}. \tag{11}$$

This expression shows that the equilibrium of hours worked depends on the idiosyncratic preferences towards working $\tilde{\psi}_i$, and two variables: the domestic trade share and the average efficiency level. If income effects dominate substitution effects, $\rho < 0$, then an increase in the domestic trade share (less trade) will increase the number of hours worked. The sensitivity of this effect is measured by $-\frac{\rho}{\theta}$. This expression captures the general equilibrium effects between hours and trade. The numerator is simply the elasticity of hours to wages and the denominator the elasticity of real

[8] Normalizing the constant $\gamma = 1$.

wages to trade. The equilibrium number of hours worked also depends on the average efficiency level. The effect of T_i has the same magnitude as the domestic trade share, but with opposite sign. With $\rho < 0$, households living in countries that are more efficient are expected *ceteris paribus* to work fewer hours.

Finally, I derive the equilibrium level of aggregate income based on fundamentals. I substitute the wage equation (10) and the equilibrium of hours (4) into the budget constraint (2). This yields aggregate income, which by definition is also equal to aggregate consumption

$$Y_i = C_i = \tilde{\psi}_i \pi_{ii}^{-\frac{(1+\rho)}{\theta}} T_i^{\frac{(1+\rho)}{\theta}} \tag{12}$$

This expression of income is more general than those in Eaton and Kortum (2002) and Waugh (2010). It incorporates labor supply adjustments to changes in real wages. Note that with an elastic labor supply with $\rho < 0$, real GDP and consumption are strictly smaller than in the case of inelastic labor supply. In the standard case of $\rho = 0$, the effect of the domestic trade share on income is simply $-1/\theta$, as in Eaton and Kortum (2002).

3.4 The leisure gains from trade

I analyze the limiting case of prohibitive trade costs and the computation of the leisure gains from trade. I define autarky by assuming infinite trade costs, $d_{in} \rightarrow +\infty \quad \forall i, n$. Therefore each country is its own lowest-cost supplier of all goods. This implies that $\pi_{ii} = 1$, and the equilibrium of hours becomes

$$H_i^{Autarky} = \tilde{\psi}_i T_i^{\frac{\rho}{\theta}}. \tag{13}$$

Hours worked are strictly higher in autarky than when there is trade.

From the equilibrium number of hours worked (11), the general equilibrium response of hours worked to changes in trade is given by

$$\widehat{H_i} = \widehat{\pi}_{ii}^{-\frac{\rho}{\theta}}, \tag{14}$$

where $\widehat{x} \equiv x^{'}/x$, with x indicating the variable in the initial equilibrium and x' in the counterfactual. The change in hours only depends on three sufficient statistics: the domestic trade share, the elasticity of hours to real wages and the trade elasticity. This approach is isomorphic to that in Arkolakis et al. (2012), in the sense that the general equilibrium effects of trade on our outcome of interest (hours) is a function of a few sufficient statistics.[9] Equation (14) provides a baseline to compute the leisure gains from trade: one hour less spent working is one hour more for leisure. To calculate the changes in hours we need a counterfactual value for trade. One simple example is to calculate the gains from moving from autarky ($\pi_{ii} = 1$) to an economy with trade ($\pi_{ii} < 1$). These gains are

[9] Arkolakis et al. (2012) show that the income gains from trade from a large class of trade models can be estimated using two sufficient statistics: the domestic trade share and the trade elasticity.

$$\frac{H_i^{Trade}}{H_i^{Autarky}} = \pi_{ii}^{-\frac{\rho}{\theta}}.$$

In Section 6, I will come back to this equation and use an alternative counterfactual for trade to quantify the leisure gains from trade over time.

3.5 Extensions to the baseline model

Here I briefly summarize possible extensions to my baseline model and show how they would affect the link between trade and hours. I individually analyze the inclusion of physical capital in production, multiple sectors, intermediate inputs, and a firm entry and exit channel. These extensions only have scale effects on the elasticity of hours-to-trade and do not modify its sign.

Table 1: Link between hours and trade with model extensions

Extension	Link of hours to trade	Notes:
Baseline	$H_i = \pi_{ii}^{\frac{-\rho}{\theta}}$	
Including capital	$H_i = \pi_{ii}^{\frac{-\rho}{(1+\alpha\rho)\theta}}$	α is the capital share
Multiple sectors	$H_i = \prod_{s=1}^{S}(\pi_{ii}^{s})^{-\frac{\omega_i^s \rho}{\theta}}$	ω^s is the consumption share for sector s
Intermediate inputs	$H_i = \pi_{ii}^{-\frac{\rho}{\lambda\theta}}$	λ is the labor share in the in production of int. inputs
Firm entry and exit	$H_i = \pi_{ii}^{-\frac{(\sigma-1)\rho}{(\sigma-1-\rho)\theta}}$	$\sigma > 1$ is the elasticity of substitution across varieties

Note: These equations present the equilibrium number of hours in the economy as a function of the domestic trade share. They are all isomorphic to Equation (11) in my model. For simplicity, I omit here the impact of T_i.

Table 1 summarizes the link between trade and hours across the different extensions. The derivations and detailed discussions can be found in Appendix C. They are all isomorphic to equation (11) in my model. I now analyze each of them.

First, it can be shown that hours worked depend on the stock of capital. If income effects dominate substitution effects, we should observe fewer hours in countries with more stock of capital, as capital income has the same effect on labor supply as labor income. However, the impact of capital on hours worked is a domestic channel, and independent from the trade openness. Compared to the baseline relationship, the elasticity of hours to trade is now multiplied by $1/(1+\alpha\rho)$, which is larger than one if income effects dominate. This channel strengthens the relationship between trade and hours, and is increasing in α.

The introduction of multiple sectors and intermediate inputs also reinforces the elasticity of hours to trade. When thinking of multiple sectors, I model a household with Cobb-Douglas consumption across sectoral goods (ω^s, with sectors indexed by s). A household that does not substitute consumption across sectors would enjoy larger *real* wage gains from a reduction in trade costs. In turn, these larger real wages, would translate into larger declines in hours worked. To extend the model to include intermediate inputs, I assume that all firms requires a composite input (assumed to be produced with Cobb-Douglas technology with a labor share λ), which is produced with CES technology and inputs that are gross substitutes. This input requirements in the composite good produces input-output loop effects across countries. When the composite good's production commands a larger share of intermediate goods, low λ, trade reduces production costs and boosts the income gains from trade. Consequentially, the magnitude of the response of hours to trade is larger (the elasticity now is multiplied by $1/\lambda$).

Finally, I study the effects of firm entry and exit as in the spirit of Melitz (2003) with monopolistic competition. In my model it is assumed that there is a fixed number of varieties, and a continuum of perfectly competitive firms producing them. Instead, now I assume that each firm produces a differentiated good, and the household derives utility from these varieties. Under these conditions, it can be shown that when allowing for endogenous firm entry and exit, the equilibrium number of firms in any country is a function of its national labor supply (market size).

When countries become more open to trade, labor supply reacts based on ρ. If income effects dominate, this leads to some firms to exit the market after hours decline, thus reducing labor demand and real wages. The endogenous adjustment of firms creates crowding-out effects on real wages and hours worked. For the relevant case of dominating income effects, the elasticity of hours to trade (11) is now multiplied by $\frac{(\sigma-1)}{(\sigma-1-\rho)}$, which is smaller than one.[10] The parameter σ is the elasticity of substitution across varieties. The crowding out effects decline as σ becomes large.

3.6 The welfare gains from trade

Now I discuss the implications of my model in terms of welfare. Compared to the canonical Eaton and Kortum (2002) model where labor supply is inelastic, the inclusion of an elastic labor supply with dominating income effects delivers an equilibrium where the representative household has more leisure (less hours worked) but less income and consumption. Despite this, welfare is even higher in the model with elastic labor supply. To show this, I compute the equivalent welfare variation $\hat{W}$ associated with an increase in trade costs. This variation measures the amount of expenditure needed to reach the counterfactual level of utility evaluated at current prices and quantified as a percentage of current expenditure.

$$\widehat{W_i} = \frac{e_i(P_i, u_i') - e_i(P_i, u_i)}{e_i(P_i, u_i)} = \frac{e_i(P_i, u_i')}{e_i(P_i, u_i)} - 1$$

where $e_i(P_i, u_i)$ is the expenditure amount required to achieve level of utility u_i in the initial trade equilibrium, and $e(P_i, u_i')$ the expenditure amount to achieve the utility level when facing higher trade costs u_i', evaluated at initial prices. The following proposition characterizes the gains from trade:

Proposition 1. *The welfare gains from trade in the model are defined by*

[10] If substitution effects were to dominate the household, then an increase in trade would lead to a rise in labor supply, which would lead to firm entry through second-round effects.

$$\widehat{W}_i = \widehat{\pi}_{ii}^{\Theta}\left[1-\frac{(1-\eta)\varepsilon}{1+\varepsilon}\left(1-\widehat{\pi}_{ii}^{-\Theta(1-\eta)}\right)\right]^{\frac{1}{1-\eta}}-1 \quad with \quad \Theta=-\frac{(1+\varepsilon)}{(1+\eta\varepsilon)\theta}<0 \tag{15}$$

These gains are larger than in Eaton and Kortum (2002) for any magnitude of income effects, as long as $\eta \neq 1$. The proof to this proposition can be found in Appendix D.

There are several points to highlight. First, the welfare gains from trade in my model are larger than those in Eaton and Kortum (2002). The elastic labor supply margin widens the utility choice set of the representative household. In other words, the new margin of adjustment makes the utility function more concave. Second, this holds irrespective from whether income effects dominate substitution effects ($\eta > 1$) or vice-versa (more on this below). If income effects were absent ($\eta \to 1$), then $\widehat{W}_i$ would converge to the case with inelastic labor supply $\widehat{\pi}_{ii}^{-\frac{1}{\theta}} - 1$. Third, an alternative expression to characterize $\widehat{W}$ is

$$\widehat{W}_i = \widehat{\pi}_{ii}^{-\frac{1}{\theta}}\left[\widehat{H}_i^{1-\eta}+\frac{(1-\eta)\varepsilon}{(1+\varepsilon)}\left(1-\widehat{H}_i^{1+\frac{1}{\varepsilon}}\right)\widehat{\pi}_{ii}^{\frac{(1-\eta)}{\theta}}\right]^{\frac{1}{1-\eta}}-1, \tag{16}$$

where the impact of trade on welfare can be decomposed into the impact of trade on wages $\widehat{\pi}_{ii}^{-\frac{1}{\theta}}$ and the labor-driven adjustment in brackets. The latter displays the effects that the changes in hours has on consumption and leisure. Consider a shift from trade to autarky with dominating income effects. The consequential decline in real wages would lead a rise in hours ($\widehat{H}_i > 1$), raising the production possibility frontier to compensate for the loss in consumption. This is the term $\widehat{H}_i^{1-\eta}$. The second term within brackets displays the negative welfare impact from the loss in leisure time due to the move to autarky. This effect is weighted by the degree of trade openness. Countries that are more open to trade would suffer a stronger utility loss from leisure if they were to move to autarky. [11] In Section 6 I provide a quantitative assessment on the welfare changes.

3.7 Discussion

This model provides a structural link between the number of hours worked and trade. Its main advantage is to derive a stylized elasticity between hours and the domestic trade share which depends only on the household's preference for leisure—the uncompensated elasticity—and the trade elasticity. The model maintains all key assumptions from Eaton and Kortum (2002), as analyzed by Arkolakis et al. (2012), in terms of preferences over goods (Dixit-Stiglitz), technology (one factor of production and linear costs) and market structure (perfect competition). In addition, the three macro-restrictions proposed by Arkolakis et al. (2012) hold: trade is balanced, aggregate profits are a constant share of revenues, and the import demand system is CES.

The model assumes a representative household which supplies homogeneous labor. This assumption allows for a simple mapping between theory and data and is informative to quantify the

[11] Note that if substitution effects were to dominate ($\eta < 1$), the effects would be reversed. The income loss from a move to autarky would further reduce welfare by less consumption (a reduction labor supply), and an increase in leisure.

average labor supply responses *across* households. However, the model remains silent regarding heterogeneity across worker types or *within* households.

My model synthesizes labor supply heterogeneity across households. Under the assumption that all households share the same preferences, the decline in hours worked predicted by the model is solely driven by labor supply responses to the *income effects* derived by trade, and not by the impact of trade-induced labor demand. The model shows that labor supply changes are a (log-linear) function of real wage changes (eq. 4). By assuming a representative household, it focuses on the aggregate response to changes in income, although the results also synthesize the decisions across heterogeneous households.

With heterogeneous households, trade would affect labor demand across sectors and occupations based on comparative advantage, thus impacting wages and employment levels along these dimensions. Those households negatively affected by trade are expected to supply more labor hours, even if they do so in other sectors and/or occupations. In the same way that the income gains from trade are such that the winners can compensate losers (Samuelson, 1939), the same equivalence holds for the leisure gains due to the hours-to-wages mapping present in my model. The "losers" from trade increase their number of hours worked, but aggregate hours decline driven by most households who are better off.

One of the main limitations of my model is that it abstracts from heterogeneous responses of labor supply at the individual level. My model is not informative on the size (or sign) of the hours-to-trade elasticity for individual workers across different dimensions, such as across demographics (age, gender), educational, sectoral, or spatial. It also abstracts from individual labor supply decisions within the household. The model predicts that the sum of the supply of work hours across its members would be lower if total household income rises after reductions in trade costs or vice versa. However, it cannot predict who will work within the household. It may well be optimal for some households to reallocate hours worked from certain family members to others, thus breaking the hours-to-trade mapping at the individual level. For example, Abman et al. (2023), find that regional trade agreements are associated with reductions in child labor.[12]

In an extension of this study, Nicolas Depetris-Chauvin and I analyze the heterogeneity of the income shock triggered by trade on hours worked across population subgroups (age, gender, education). We find that all workers benefit from more leisure. However, there are large differences across workers. Overall, the relative leisure allocation is aimed at low-income workers. More leisure gets allocated to the young and elder workers. In addition, women and less educated workers also benefit relatively more (Depetris-Chauvin and Velasquez, 2024).

[12] In a recent study, Lee (2020) expands the Eaton and Kortum (2002) model to include heterogeneous workers by assuming a continuum of workers which have idiosyncratic sector- and occupation-specific efficiency levels conditional on different education types. She finds that trade raises labor income of for all workers-in absolute terms-and that the education-based income inequality increases in both developed and developing countries. Across sectors and occupations, however, trade leads to reallocation of labor towards the sectors with more comparative advantage (e.g. a shift from manufacturing towards services in the US). Another study looking at these heterogeneous effects is Galle et al. (2023).

One important drawback of the model is the absence of labor market adjustment dynamics. By construction, the model only studies change in static general equilibria and omits labor transitions among them. In other words, the model implicitly abstracts from any labor mobility frictions across sectors or space. As it has been largely documented in the literature (see Autor et al. (2013) and many others), a sudden change in terms of trade, may cause some sectors and regions to display declining hours and wages, and an pick up in unemployment. This demand-driven impact is temporary, and workers become employed in other sectors and regions over time (Dix-Carneiro and Kovak, 2019). For example, Galle et al. (2023) find that trade liberalization leads to an increase in unemployment at the national level, but that it short-lived, usually disappearing after three years.

4 Bringing the Model to the Data

The derivations in the previous section display a structural link between trade and hours worked through income. In this section, I propose an empirical analysis with two objectives. The first one is to provide a causal interpretation the structural equations of my model. The second objective is to recover: i) the elasticity of hours to wages, to show that income effects dominate substitution effects, and ii) the trade elasticity. I will later calibrate my counterfactual exercises based on these parameters.

In Section 4.1, I illustrate the connection the model's structural equations and my econometric specifications. In Section 4.2 I present the identification strategy and the construction of a geography-based instrument for trade, and in 4.3 I describe the data for the empirical analysis.

4.1 Estimating the model's structural equations

The main objective of my empirical analysis is to identify the causal effect of trade on hours worked at the country level. Based on the equilibrium number of hours worked (eq. 11), the model shows that the structural relationship between hours worked and the domestic trade share (π_{ii} in the model) takes the log-linear form

$$\log h_{it} = \lambda_i + \lambda_t + \beta^H \log DomesticTradeShare_{it} + \varepsilon_{it}^H \qquad \text{with} \quad \beta^H \equiv -\frac{\rho}{\theta}, \tag{17}$$

where time subscripts are added to random variables. λ_i and λ_t are country and year fixed effects, respectively, and ε_{it}^H is the error term. In turn, ε_{it}^H can be explicitly defined as $\varepsilon_{it}^H = T_{it} + l_{it} + \tau_{it} + e_{it}$. T_{it} represents time-varying productivity, l_{it} time-varying preferences (or "tastes") for leisure, τ_{it} are time-varying policies (e.g., taxes) that may affect labor supply, and e_{it} is a stochastic error term.

The specification requires a common denominator to compare hours worked across countries. In (17), h_{it} is defined as hours worked *per worker*. This is the closest to the model's assumptions: the household is *de facto* employed and only adjusts how many hours it works. Following the evolution of hours worked per capita over time depicted in Figures 4a and 4b, we can expect that most adjustment of hours to income changes are along the intensive margin.[13]

β^H captures the elasticity of hours worked to domestic trade share. As discussed in the previous section, β^H is a function of the elasticity of hours to wages ρ and the trade elasticity θ. If income effects dominate the substitution effects in households preferences $\rho < 0$, then we expect to observe $\beta^H > 0$. That is, households decide to reduce their labor supply following a rise in real wages triggered by trade. But, if income and substitution effects cancel out, we would have $\rho = 0$ and β^H should not be significantly different from zero. This means that labor supply does not react to changes in real income. The coefficient β^H in (17) can be considering as capturing the general equilibrium effects of trade on hours worked.

In a second step, I estimate the impact of trade on income, with aims to recover the estimate of the Marshallian elasticity ρ in my model. Applying a logarithmic transformation to equation (12) yields:

$$\log y_{it} = \lambda_i + \lambda_t + \beta^Y \log DomesticTradeShare_{it} + \varepsilon^Y_{it} \quad \text{with} \quad \beta^Y \equiv -\frac{(1+\rho)}{\theta}. \tag{18}$$

The coefficient of interest β^Y, measures the response of income per worker to changes in the domestic trade share. β^Y captures the general equilibrium effects of trade on income as a function of the elasticity of hours worked to wages and the trade elasticity. If trade has a positive effect on income, then we would expect $\beta^Y < 0$. This specification is akin to the those in Frankel and Romer (1999); Feyrer (2019, 2021) and others.

Equations (17) and (18) are based on the model's structural equations (11) and (12), respectively. According to the model, if more trade increases income $\beta^Y < 0$, then hours worked should decline with more trade, $\beta^H > 0$. Besides corroborating the expected signs of the coefficients, this empirical analysis allows me to recover the value of the underlying parameters of the model, and cross-check their values to evaluate the model's internal consistency.

4.2 The identification strategy

This paper claims that trade has a causal impact on hours worked. To identify this effect, it must be that the domestic trade share is orthogonal to all components of ε^H_{it}. However, a simple ordinary least squares (OLS) estimation of (17) would suffer from endogeneity. An omitted variable bias would arise due to the impact of domestic productivity on the domestic trade share (the impact of T_i on π_{ii} in the model, see (9)). At the same time, we know that higher domestic productivity leads to lower hours worked (11). Thus, this would create a negative bias on β^H using OLS.[14] Additional endogeneity may appear with regards of institutional reforms. For example, free trade agreements or broader trade reforms may be carried out simultaneously with labor market reforms and wider institutional changes. This is increasingly the case as modern trade agreements tend to get "deeper", including provisions on various domestic regulations such as on labor markets. To

[13] In Section 5.2 I also investigate the effects of trade and income on the employment rate.

[14] The sign of the bias would depend on $COV(H,T) \cdot COV(\pi,T)$, where the first covariance is negative and the second one positive.

remove these sources of endogeneity, I rely on an IV approach.

4.2.1 A time-varying instrument based on geography

To identify exogenous variation in domestic trade shares, I use Feyrer (2019)'s geography-based instrument. He uses the development of air transportation technology between 1950 to 1995 as an exogenous shifter of trade costs. During this time period, technological improvements in aviation significantly reduced air freight costs. This allowed exporters of certain goods (mostly with high value-added content) to shift their exports from shipping towards air transportation. Country-pairs that had shorter air routes relative to sea routes benefited more than countries where air and sea routes were more similar.

Capturing the implicit difference in the development in air transportation relative to that of shipping gives the instrument a time dimension, allowing to control for country fixed effects. In addition, the geographic nature of the instrument makes it exogenous to several 'deep determinants' of income, therefore eliminating any reverse causality concerns. This instrument has also been used to study the effects of economic integration on political alignment (Kleinman et al., 2022), and on individual's democratic values (Magistretti and Tabellini, 2023). [15]

I now present the steps to build Feyrer (2019)'s time-varying instrument based on geography. His instrument is based on the structure of the gravity equation. Therefore, focusing on trade flows is a natural starting point. From my model, the trade share equation (7) can express trade flows between two countries. As discussed in Section 3, these flows are subject to trade costs. Therefore, I can express total bilateral imports of country i from country n in year t as

$$\log Imports_{int} = \lambda_i + \lambda_n + \lambda_t - \theta \log d_{int},$$

where λ represents exporter, importer and year fixed effects. d_{int}, the bilateral trade cost, enters negatively in its relation with trade flows. d_{int} is a function of many observable and unobservable country-pair characteristics such as distance, transport technology, tariffs, common language, etc.

As is common in studies that estimate the gravity equation, I assume that trade costs affect trade flows in a log linear way. Assuming that all country pairs share the same bilateral trade costs for each period, this cost variable can be written as a function of air distance and sea distance

$$\log d_{int} = \beta_{air,t} \log airdist_{in} + \beta_{sea,t} \log seadist_{in}.$$

This expression shows that changes in bilateral trade costs are a function of the distance between the two countries by sea and by air. Including a time dimension allows the coefficients of sea and air distance to vary over time. Each of them captures the relative change in technology in both sea and air transportation. As Feyrer (2019) points out, the value of β is less important than its evolution over time. A positive change in β indicates a higher weight in its relative importance with respect

[15] Others studies have also constructed geography-based instruments based on the gravity equation. For example, Pascali (2017) uses the same steps as Feyrer (2019), but using the shift in transportation technology from sailing towards steam-engine shipping.

to the alternative transportation technology. The objective is to estimate β at different periods of time to capture the change in transportation technology. I estimate the β's from the following econometric specification

$$\log Imports_{int} = \lambda_i + \lambda_n + \lambda_t + \beta_{air,t} \log airdist_{in} + \beta_{sea,t} \log seadist_{in} + \epsilon_{int}. \tag{19}$$

Including exporter, importer and year fixed effects controls for all other characteristics that affect the bilateral trade relationship (such as the GDP of any trading partner). Year fixed effects control for any growing trends such as factor costs.[16]

Using the estimated β's, I build my instrument for domestic trade, which I call predicted trade, as a weighted average of all bilateral imports of country i.[17] It is defined as

$$\log PredictedTrade_{it} = \log \sum_{i \neq n} \omega_{in} e^{\hat{\beta}_{air,t} \log airdist_{in} + \hat{\beta}_{sea,t} \log seadist_{in}} \tag{20}$$

where ω_{in} are weights. This equation defines the predicted trade variable that will be used as an instrument for the domestic trade share in my empirical exercise. The summation indicates a weighted average on the effect of time-varying transportation technology. The variables $airdist_{in}$ and $seadist_{in}$ are exogenous and time invariant. The evolving $\hat{\beta}_{air,t}$ and $\hat{\beta}_{sea,t}$ capture the relative importance of technological advances in air and sea transportation that are common to all countries.

The construction of my instrument is inspired by the gravity formulation detailed in Feyrer (2019), who specifies the instrument as

$$PredictedTrade_{it} = e^{\hat{\lambda}_i + \hat{\lambda}_t} \sum_{i \neq n} e^{\hat{\lambda}_n + \hat{\beta}_{air,t} \log airdist_{in}}$$

$$\log PredictedTrade_{it} = \hat{\lambda}_i + \hat{\lambda}_t + \log \left(\sum_{i \neq n} e^{\hat{\lambda}_n + \hat{\beta}_{air,t} \log airdist_{in} + \hat{\beta}_{sea,t} \log seadist_{in}} \right) \tag{21}$$

Given that is fully relying on the gravity structure, equation (21), maximizes predictive power of the instrument by using fixed effects as weights. However, the domestic trade share is a non-linear function of trade flows. These non-linearities would not satisfy the exclusion restriction if fixed effects were to be included in the construction of the instrument. For this reason, the use of instrument (20) is favored over (21) for the within analysis.[18] In principle, any type of weight ω could be used in (20). I use the average bilateral trade share between n and i, relative to total imports of i, of the first 5 years of available data. My results are robust to employing alternative weights such as exporter's initial population size or initial trade volume.[19]

[16] A variation of this specification is to include country-pair fixed effects, λ_{in} instead of exporter plus importer fixed effects. My empirical results are not sensitive to this change in the construction of the instrument.

[17] Given that my model assumes balanced trade, aggregate imports in any country should be the same as aggregate exports. I refer to any of these terms simply as $Trade$.

[18] I thank the editor and one anonymous referee for highlighting this point.

[19] Table A3 in Appendix E reports this sensitivity analysis.

4.2.2 Discussion

I use predicted trade to identify changes in domestic trade shares. The domestic trade share is defined as one minus the import penetration ratio:

$$DomesticTradeShare_{it} = 1 - \frac{Trade_{it}}{Expenditure_{it}}, \tag{22}$$

where $Trade$ refers to the total value of imports and $Expediture$ refers to total expenditure in the domestic economy. From this equation, it is clear why predicted trade is a relevant instrument for the domestic trade share. First, cross-country variation in predicted trade reflects cross-country differences in trade given each country's distance from trading partners. This suggests that $Trade$ and predicted trade must be highly correlated. Second, predicted trade is built solely on geographic distance and the technological developments in air and shipping transportation. Therefore, it is orthogonal to any changes in $Expenditure$ that are not caused by trade. Countries that have more predicted trade are expected to have smaller domestic trade shares.

Predicted trade also satisfies the exclusion restriction. We could think of a violation of the exclusion restriction if predicted trade is correlated with any determinant of hours other than trade, or any determinant of income other than trade. Feyrer (2019) discusses the latter point in detail, so I will focus on the former one.

One could think about other determinants of labor supply in the error term ε_{it}^{H} in (17) for possible violations to the exclusion restriction. First, my instrument is assumed to be independent from domestic productivity growth (T_{it}). Advancements in air transportation technology are assumed to be available for all countries, and uncorrelated with productivity in any specific one. This is the main point in Feyrer (2019). He shows that the effects of trade on income are robust to heterogeneous growth trends across regions and differences in industry structure.[20]

Second, given that the construction of the instrument depends solely on geographic distance and the reduction of air transportation technology, it is orthogonal to any time-varying changes in domestic policies and institutions (τ_{it}), e.g. taxation and labor legislation. In addition, country fixed effects wipe out the influence from cultural factors towards work, institutions, weather conditions, among many other time-invariant factors (in the model represented by $\tilde{\psi}_i$).

Finally, my instrument is also assumed to be exogenous to time-varying changes in leisure tastes (l_{it}). One argument raised by Aguiar et al. (2021) is that the price decline of goods that are complimentary to entertainment (e.g., video games) has caused a decline in hours worked for young men in the US. While cheaper air transportation technology reduced the transport costs of electronics, it also did so for other goods that are not complimentary to leisure activities (these are goods that require time for their consumption). As discussed in Feyrer (2019), most of the transported goods by air comprise high value-added products: pharmaceuticals and organic chemicals, luxury goods (such as watches, works of art, and leather goods), precious metals and jewelry, as well as perishable

[20] As a robustness check, I try a specification for (17) that controls for a measure of total factor productivity and physical capital per worker. I find no significant differences between my baseline results and the ones including these controls. The results are presented in the Appendix E.

goods (e.g., fish and flowers). A violation of the exclusion restriction would require that the impact of my instrument on the set of goods complimentary to leisure to be larger than on the rest of the consumption basket. The analysis on the transported goods does not suggest a concern in this regard. Note also that time fixed effects wipe out any changes in preference towards leisure that are common across countries.

4.3 Data

I employ a country-year panel covering 45 countries spanning between 1950 and 1995. The time coverage is limited by the construction of the instrument for trade.[21]

Data on hours worked, population and real GDP are from the Penn World Table (PWT) version 9.0. PWT reports country-year data on actual annual hours worked per worker, employment (total number of persons engaged) and population. Data on hours worked reflect the effective hours of paid (and unpaid) work by employees plus self-employed workers. It excludes any paid, unworked hours (such as holidays, sickness or maternity leave, annual paid leave, meal breaks, etc.), commuting time and work time lost due to strikes. While compiled by national accounts, the main source of actual hours worked is labor force surveys.[22] Compared to data on employment (which is reported for a larger number of countries), PWT reports unbalanced data on hours per worker for 45 countries between 1950 and 1995 (my period of analysis). Bick et al. (2018) point out that PWT data for low-income countries may suffer from interpolation and/or extrapolation, making them less reliable for cross-country analysis.[23]. For robustness, I replicate my empirical analysis on a subsample of OECD countries that may have higher quality data. The results are robust to excluding low- and middle-income countries (see Appendix E).

I build the domestic trade share using PWT data, as in Waugh and Ravikumar (2016). It is defined as one minus the ratio of imports-to-GDP at current prices. Alternative measures, such as imports-to-gross spending, tend to make countries look more closed to trade than what they actually are because they omit global input-output linkages. As discussed in Costinot and Rodrıguez-Clare (2018) and Johnson and Noguera (2012), once these linkages are accounted for, the import share in any country is much closer to imports-to-GDP share than to imports-to-gross-spending.[24] Discrepancies in the measurement of the domestic trade share may have a small influence on the level of the estimated coefficient, but no effects on its inference. To limit the influence of outliers, I drop countries that have a domestic share outside of the interval 0.5 - 1 as well as those with less

[21] As pointed out by Feyrer (2019), between 1955 and 2004 the cost of air freight declined by a factor of ten, with most of the decline happening before 1972. Focusing on this time period allows to maximize the variability of the instrument. See Appendix F for the list of countries included in the analysis.

[22] Hours per capita are defined as hours per worker multiplied by the employment rate.

[23] Bick et al. (2018) collected data on labor force surveys across a large sample of countries (many of them low-income) and made adjustments to improve comparability between countries. However, their data does not allow me to control for country fixed effects as it does not have a time dimension. I use Bick et al. (2018) data on hours worked for the cross-country figures of Section 2 and the counterfactual analysis in Section 6.

[24] Nonetheless, both measures of import share are highly correlated. For example, for the period 2000-14, I find a correlation of 0.83 among the two variables.

than one million inhabitants.

The instrument predicted trade is built following the same steps and data from Feyrer (2019). Trade flows are from the International Monetary Fund's Direction of Trade Statistics (DOTS), they are computed as the average of the four recordings of bilateral trade flows by country pair (exports and imports reported by each bilateral partner). In this way, the trade data is modified to reflect balanced trade, as assumed in the model. Air distance is measured as the bilateral great circle distances, provided by the CEPII. Sea distance is calculated by Feyrer (2019) using geographic data and an algorithm that minimizes the travel time between country pairs.

Descriptive statistics are presented in Table A5. The panel is unbalanced. This can be problematic if the missing values in hours worked or trade lead to sample selection bias. To verify this is not the case, I replicate the main analysis on a subsample of countries with balanced observations of hours worked and trade. I do not find significant differences from the unbalanced panel.

5 Econometric Results

In this section I present the econometric results. In Section 5.1 I estimate the causal effects of trade on hours per worker through income. Section 5.2 studies the same impacts on the employment rate. In Section 5.3 I recover the parameters of my model from the estimated coefficients. Finally, in Section 5.4 I provide some robustness analyses.

5.1 The impact of trade on hours per worker

I present the estimation results of regressing of hours per worker on the domestic trade share (17) in Table 2. Column 1 shows the OLS estimation with country and year fixed effects. Standard errors are clustered at the country level. The point estimate for the domestic trade share on per worker hours worked is positive and marginally significant. Column 2 in Panel A shows the IV results using predicted trade as an instrument. The estimated coefficient is 0.507, almost doubles the OLS one, and is statistically significant at the five percent level.[25] This result shows that being more closed to trade (a higher domestic trade share) is a causal factor leading to more hours worked. Panel B presents the first stage results. As expected, it shows a negative and statistically significant coefficient. Countries that are predicted to trade more, based on their relative distance with other countries, tend to have a smaller domestic trade shares. The F-statistic is 15.45, which is larger from the usual threshold of 10 to evaluate a weak IV (Stock and Yogo, 2005). Panel C shows the reduced-form results. It exhibits a negative and highly significant coefficient. A one percent increase in predicted trade is associated with a 0.1 percent decline in hours worked.

In Table 3, I show the results for long-differences. I take 10-, 15- and 35-year differences of specification (17) and my instrument (20). In addition, I also use the gravity formulation of the instrument (21) in long-differences. All columns include year fixed effects. Panel A shows the second stage results, reporting that the size of the coefficient 'in differences' is similar to that using

[25] As previously discussed, the OLS estimate is subject to a downward bias.

Table 2: Trade and hours per worker

	(1)	(2)
Panel A: Second stage		
	Dependent variable: log hours per worker	
	OLS	IV
log domestic trade share	0.253*	0.507**
	(0.128)	(0.217)
R^2	0.084	
Panel B: First stage		
	log domestic trade share	
log predicted trade		-0.160***
		(0.041)
F-stat		15.45
First stage R^2		0.182
Panel C: Reduced form		
	log hours per worker	
log predicted trade		-0.081**
		(0.039)
Reduced form R^2		0.061
Country and year FE	yes	yes
Observations	321	321
Countries	45	45

Note: This table reports OLS and IV estimates of regressing hours per worker on the domestic trade share and trade volumes. The panel comprises 5-year intervals of data between 1950 and 1995 for 45 countries. All specifications include country and year fixed effects. The instrument log predicted trade is constructed based on equation (20). The F-stat is the Kleiberg-Paap Wald F-statistics for weak identification. Standard errors (reported in parentheses) are clustered at the country level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 3: Trade and hours per worker: long time differences

	(1)	(2)	(3)	(4)	(5)	(6)
			Dependent variable:			
			Δ log hours per worker			
	10 years	15 years	35 years	10 years	15 years	35 years
Panel A: Second stage						
Δ log domestic trade share 10 years	0.337			0.529		
	(0.320)			(0.462)		
Δ log domestic trade share 15 years		0.497			0.663*	
		(0.324)			(0.361)	
Δ log domestic trade share 35 years			0.585**			0.611***
			(0.221)			(0.178)
Panel B: First stage						
Δ log predicted trade (weights) 10 years	-0.048					
	(0.033)					
Δ log predicted trade (weights) 15 years		-0.058				
		(0.035)				
Δ log predicted trade (weights) 35 years			-0.108**			
			(0.0498)			
Δ log predicted trade (gravity) 10 years				-0.052*		
				(0.026)		
Δ log predicted trade (gravity) 15 years					-0.060**	
					(0.026)	
Δ log predicted trade (gravity) 35 years						-0.105**
						(0.038)
Observations	230	194	69	230	194	69
Time period FE	yes	yes	yes	yes	yes	yes
F-stat	2.633	7.43	8.994	2.090	5.934	13.72
First stage R^2	0.085	0.110	0.135	0.096	0.129	0.223
Countries	36	35	24	36	35	24

Note: This table reports IV estimates of regressing hours per worker on the domestic trade share in differences. The specfications comprise 5, 10 and 35 year long differences between 1950 and 1995 of a sample of 45 countries. All specifications include time period fixed effects. The instrument log predicted trade (weights) is constructed based on equation (20) and log predicted trade (gravity) based on equation (21). The F-stat is the Kleiberg-Paap Wald F-statistics for weak identification. Standard errors (reported in parentheses) are clustered at the country level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 4: Estimating the income channel

	(1)	(2)	(3)	(4)
Panel A: Second stage				
		Dependent variable: log GDP per worker		
	OLS	IV	IV	OLS
log domestic trade share	-0.722*	-3.619**	-3.544**	
	(0.427)	(1.500)	(1.549)	
log predicted trade				0.579***
				(0.147)
R^2	0.036			0.165
Panel B: First stage				
		log domestic trade share		
log predicted trade		-0.160***	-0.115***	
		(0.041)	(0.037)	
F-stat		15.45	12.33	
Observations	321	321	631	321
Country and year FE	yes	yes	yes	yes
Countries	45	45	87	45

Note: This table reports the OLS and IV estimates of regressing real GDP per worker on the domestic trade share (eq. 18). The panel comprises 5-year intervals of data between 1950 and 1995 for 87 countries. All specifications include country and year fixed effects. The instrument log predicted trade is constructed based on equation (20). The F-stat is the Kleiberg-Paap Wald F-statistics for weak identification. Standard errors (reported in parentheses) are clustered at the country level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

the within-estimator reported in Table 2. Both results show that the impact of trade on hours worked materializes over long periods. Panel B reports the first stage. The magnitude of the coefficient in long differences in predicted trade is similar to the one employing the within estimator. Both sets of instruments reveal that the impact of trade on hours only materializes over long periods (10 years and more). The longer the period considered, the largest the F-stat and first stage R^2. As expected, the instrument based on the gravity equation has the larger F-stat and first stage R^2 when considering the 35-year difference.

I now show that trade has a positive causal effect on income. Based on specification (18), I present the results of regressing GDP per worker on the domestic trade share for those country-years of which hours per worker data are available. Table 4 presents the results. Column 1 displays the OLS estimates. It shows a negative and marginally significant coefficient of domestic trade share on income per worker. Its magnitude increases when I instrument domestic trade share with predicted trade in column 2. The coefficient of -3.2 is statistically significant at the 5 percent level. Column 3 relaxes the restriction of country-years that have available data on hours per worker. Observations nearly double from 321 and 45 countries to 631 and 87 countries. Nonetheless, the estimated coefficient remains unchanged. These findings reveal a positive effect of trade on income per worker: countries that are more closed to trade have lower income. This causal effect of trade on income is in line with those reported by Frankel and Romer (1999), Feyrer (2019, 2021), among others. Column 4 displays the reduced form results, and panel B the First Stage for the IV regressions.

In sum, I find empirical support for the structural equations displayed in my model and for the assumption that income effects dominate substitution effects. Hours per worker decline with higher income, and trade raises income. As a consequence, workers spend more time working in countries that are more closed to trade.

5.2 The impact of trade on the employment rate

I explore whether trade or 'trade-generated' income effects have an impact on the equilibrium level of employment. I modify my specification of trade on hours per worker (17) and replace hours per worker with the employment rate as a dependent variable. This allows me to estimate the causal effect of the domestic trade share on the employment rate. One difference with the previous analysis is the number of observations and countries in the sample. 87 countries report employment rate data compared to only 45 reporting hours per worker.

Table 5 presents the results. Column 1 shows the estimated impact of trade on the employment rate with OLS on the sample of countries that have available data on hours per worker. It reports a non-significant point estimate. Using predicted trade as instrument for the domestic trade share, column 2 reports the second-stage IV point estimate. It displays a positive coefficient, which means that an increase in trade may cause lower employment. However, the coefficient is marginally significant (at the 10 percent level only). Columns 3 repeats the IV regression but on the sample with all countries that have available data on employment rates. There is no significant effect of trade

Table 5: Trade and the employment rate

	(1)	(2)	(3)	(4)
	log employment rate			Δ log employment rate (35 years)
	OLS	IV	IV	IV
log domestic trade share	0.0248	0.814*	0.343	
	(0.149)	(0.477)	(0.402)	
Δ log domestic trade share 35 years				0.705
				(0.505)
Observations	321	321	631	97
Country FE	yes	yes	yes	
Year FE	yes	yes	yes	yes
F-stat in first stage		15.45	12.33	11.35
Countries	45	45	87	37

Note: This table reports the results of regressing the employment rate on the domestic trade share in both levels and long-run differences. The panel comprises 5-year intervals of data between 1950 and 1995 for 87 countries. Columns from 1-3 include country and year fixed effects, and 4 year fixed effects. The instrument log predicted trade is constructed based on equation (20). The F-stat is the Kleiberg-Paap Wald F-statistics for weak identification. Standard errors (reported in parentheses) are clustered at country level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

on employment rate, even at the 10 percent level. Finally, column 4 re-estimates the specification of column 2, but using 35-year long differences. Results show no significant effect of trade on the employment rate. The F-stat for the instrument for trade is above the 10 threshold in all IV regressions.

The results along the different margins of hours suggest that the decline in hours per capita is through the hours per worker, with no sound evidence of adjustment along the employment rate. This is consistent with the stylized facts on the long-run behavior of per capita hours worked described in Section 2. As shown in Figures 4a and 4b, the long-run decline of per capita hours is driven by the decline along the intensive margin. The extensive margin, on the other hand, is stationary throughout the second half of the 20th century.

5.3 Recovering the parameters of the model

As discussed in Section 4.1, the estimated coefficients from the econometric specifications are based on underlying parameters of my model. I now recover these parameters to link them to the theoretical model.

First, I recover the elasticity of hours worked to real wages ρ. To this aim, I divide the coefficient of hours on the domestic trade share, β^H from (17), by the coefficient of income on the domestic trade share, β^Y from (18). This procedure eliminates the need to know θ to recover ρ. Rearranging the ratio of these coefficients yields $\rho = (\beta^Y/\beta^H + 1)^{-1}$.

Table 6 presents the recovered parameters. The recovered Marshallian elasticity ρ yields -0.16.

Table 6: Recovered parameters from the estimated coefficients

ρ	θ	
	method I	method II
-0.16	0.32	0.23

Its negative sign provides evidence that income effects dominate substitution effects ($\eta > 1$ in the model). The magnitude of ρ, which from the labor supply equilibrium (4) captures the response of hours to wages, is in line with values found in micro studies, such as Cesarini et al. (2017), and those calibrated in macro studies. Boppart and Krusell (2020) suggest that ρ should be equal to -0.2 to match the long-run decline in hours worked. Bick et al. (2019c) calibrate ρ = -0.1 in a model to explain declining hours as a function of income, while Heathcote et al. (2014) input a -0.19 value in a Aygari-type of model.

ρ is, in turn, a function of the inverse of the intertemporal elasticity η and the Frisch elasticity ε. Having recovered a value for ρ, one can now create a link between these two preference parameters. The values of η should be such that $\eta = (1-\rho/\varepsilon)(1+\rho)^{-1}$. Using this equation and a fixed value for ρ, one can back out η from inputed values of the Frisch elasticity that can be found in the literature. For example, Chetty et al. (2011), who review the literature on labor supply elasticity estimation, suggest the use of $\varepsilon = 2.84$ when modeling aggregate hours worked, and $\varepsilon = 0.82$ when modeling only the intensive margin. These values yield an η of 1.26 and 1.42, respectively. For a given ρ, the inverse relationship between η and ε implies that a more impatient household (higher η) should have preferences displaying less disutility to work (lower ε).[26]

Next I recover the implicit trade elasticity θ. For this I focus again on the estimated coefficients of β^H and β^Y. Using equations (17) and (18), θ can be recovered as $\theta = -\frac{\rho}{\beta^H}$ (method I) or $\theta = -\frac{(1+\rho)}{\beta^Y}$ (method II). Fitting $\rho = -0.16$ and the estimated parameters yields the recovered values for the trade elasticity. Table 6 shows the results. Both values of θ are similar to each other and close to 0.25. Backing out similar θ from different specifications demonstrates a tight consistency between the model and the empirical exercise, and reveals that the size of θ is not affected by potential measurement errors in hours worked.

The θ I recover is significantly lower than the usual trade elasticities found in the trade literature. Estimates of θ based on bilateral trade flows range between 2 and 8 (Eaton and Kortum, 2002), with most studies reporting a value close to 4 (Simonovska and Waugh, 2014).[27] θ smaller than 4 implies larger income gains from trade. The magnitude of these income gains are, however, common in studies analyzing the impact of trade on GDP (Frankel and Romer (1999), Feyrer (2019), and others). As Donaldson (2015) points it out, there seems to be a gap in the literature between the θ estimated on bilateral trade flows using gravity equations, and that one implied by the impact of

[26] The lower bound for η, with $\rho = -0.16$ and $\varepsilon \to +\infty$, is 1.19.

[27] To recover $\theta = 4$, β^H would need to fall from 0.51 to 0.05. In addition, if we were to assume $\theta = 4$, given $\hat{\beta}^H$, the recovered ρ would be -2 (see eq. 17). Implying that after a one percentage point increase in real wages, labor hours would decline by 2 percent (an inconsistent amount).

trade on GDP in cross-country studies.

One possible answer to this gap is that the estimated trade elasticities are different. As analyzed recently by Boehm et al. (2023), $\theta \approx 4$ represents a "short-term" trade elasticity. Studies that estimate such elasticity usually do so by accounting the response of trade flows to immediate changes in bilateral tariffs, or temporary disruptions in transportation costs (Feyrer, 2021). These elasticities do not incorporate income gains from trade that may take time to materialize. For example, traded goods may have technology or ideas embedded in them that need time to diffuse. Following a change in the terms of trade, the reallocation of production factors towards sectors with comparative advantage is also a lengthy process. Boehm et al. (2023) show that when the estimation is carried out over longer horizons (controlling for short-run confounders), the magnitude of the long-run trade elasticity in gravity specifications becomes smaller. Utilizing local-projections, they estimate that the long-run elasticity is reached between 7 to 10 years after the change in the terms of trade.[28] They suggest utilizing a trade elasticity of 1 when employing the Arkolakis et al. (2012) type of formula for counterfactuals.

A trade elasticity of 1 is still larger than my estimated trade elasticities. What other factors may affect the recovery of θ? One possibility is that the estimated β^H may be capturing local average treatment effects (LATE). If there are heterogeneous treatment effects, the IV would be picking up the LATE of countries that benefited significantly more from the reduction in air freight costs, yielding a larger β^H. A larger β^H would imply a smaller recovered θ. A second factor is the underlying model's production assumptions. I recovered θ as the residual of β^H. If the model is extended to include a more complex production structure, such as capital in production or intermediate inputs (see Table 1), these mechanics would account for a larger share of the income gains from trade, thus returning a larger implied θ.

For my counterfactual simulations, I use the value of $\theta = 1$ (in line with Boehm et al. (2023)). The reasons for this are twofold. First, it is a conservative value. Although my estimates suggest $\theta \approx 0.25$, the possible effects of LATE and/or an omission in production when recovering θ, call for a prudent approach to not over estimate the impact of trade on income. The second reason is grounded in my model's assumptions, as it is assumed that θ should not be smaller than 1.

To sum up, there is a consistent mapping between the estimated coefficients of the empirical analysis and the implied parameters of my model. The elasticity of hours worked to real wages is close to -0.16, a value that is plausible given the long-run decline in hours worked. The results also imply a low trade elasticity, which translates into sizable income gains from trade. For the counterfactual exercises, I use $\theta = 1$ (as suggested by Boehm et al. (2023)).

[28] Their estimation procedure compares changes in small countries' (with MFN tariffs) trade flows to a control group of exporters (without MFN tariffs) to the same country. They use local projection methods to separate the time-dimension of trade elasticities.

5.4 Robustness analysis

In this section I provide evidence on the strength of the instrument's exclusion restriction. First, country fixed effects wipe out any influence from time-invariant factors, such as cultural attitudes towards work, geographic location, weather conditions, among many others. Second, a geography-based instrument should be orthogonal to all time-varying determinants of hours worked other than trade. For the exclusion restriction to fail, it must be the case that such variable should be correlated with the development of air transportation in the second half of the 20th century. I show that my main results hold when controlling for three common time-varying determinants of hours worked.

First, I control for the share of government spending over GDP as a proxy for the tax burden faced by the average household in the economy. Second, I include a measure of the tax wedge used in Ohanian et al. (2008) for a subsample of OECD countries. This tax wedge captures the loss in labor income (in consumption terms) that the average household faces.[29] Third, I control for the level of democracy. For example, if workers live in more democratic countries, they may have more power to enact pro-worker rights and labor legislation compared to those living under authoritarian regimes. With this aim, I include a measure of constraint on the executive from Polity IV. This variable measures whether executive power is constrained by checks, balances and the rule of law. It is bounded between 1, where there is no constraint, and 7, where the executive branch is subject to strong accountability mechanisms.

Table 7 shows the results. Column 1 regresses hours per worker on the effects of the domestic trade share. Columns 2-4 add the mentioned determinants of hours as controls. The coefficient of the domestic trade share remains broadly unchanged. It only grows in magnitude when controlling for the tax wedge, which may also be driven by the lower number of countries. This evidence suggests that exclusion restriction holds when controlling for the most popular drivers of hours worked across countries (Bick et al., 2019a). In Appendix E I extend the sensitivity analysis. I show that my main results are robust to controlling for TFP and physical capital, that they are not driven exclusively by low- and middle-income countries, and robust to alternative weights in the construction of the IV.

[29]The tax wedge is $(1-\tau)$, where τ is a composite tax rate defined as $\tau = \frac{\tau^{labor}+\tau^{cons}}{1+\tau^{cons}}$. τ^{labor} includes total government revenue from taxes on labor income (including social security contributions) divided by the total labor income at national level. τ^{cons} is total government revenue from consumption goods, including value-added tax plus excise taxes on consumption goods divided by total private consumption. See Ohanian et al. (2008).

Table 7: Robustness analysis: controlling for taxes and democracy

	(1)	(2)	(3)	(4)
	Dependent variable: log hours per worker			
log domestic trade share	0.507**	0.517**	0.864**	0.482**
	(0.217)	(0.213)	(0.216)	(0.228)
gov. spending (% of GDP)		-0.130		
		(0.117)		
tax wedge			-0.311**	
			(0.154)	
log constraint on executive				-0.005
				(0.006)
Observations	321	321	111	161
Country and year FE	yes	yes	yes	yes
F-stat in first stage	15.45	15.88	24.71	14.22
Countries	45	45	12	20

Note: This table adds controls to the IV estimation of (17). The panel comprises 5-years intervals of data between 1950 and 1995 for 45 countries. The instrument log predicted trade is constructed based on equation (20). All columns include country and year fixed effects. The F-stat is the Kleiberg-Paap Wald F-statistics for weak identification. Standard errors (reported in parentheses) are clustered at the country level. For regressions with fewer than 45 countries, I report Huber-White robust standard errors instead. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

6 Quantifying the Leisure Gains from Trade

Previous sections showed through theory and empirical evidence that trade reduces the supply of labor hours, thus increasing leisure time. In this section, I gauge the magnitude of the leisure gains in actual hours for different countries. To this aim, I perform two exercises. First, I quantify how much trade openness contributed to the long-run decline in hours worked between 1950-2014. Second, I quantify the upper bound of potential leisure loss from a hypothetical move from current levels of trade to autarky. Finally, I provide a quantitative assessment of the welfare gains from trade.

Figure 4a shows that hours per worker have declined in the second half of the 20th century in most countries. Now, I quantify how much trade openness contributed to this trend. Based on the equilibrium number of hours worked (11), I build a counterfactual series of hours per worker in autarky as

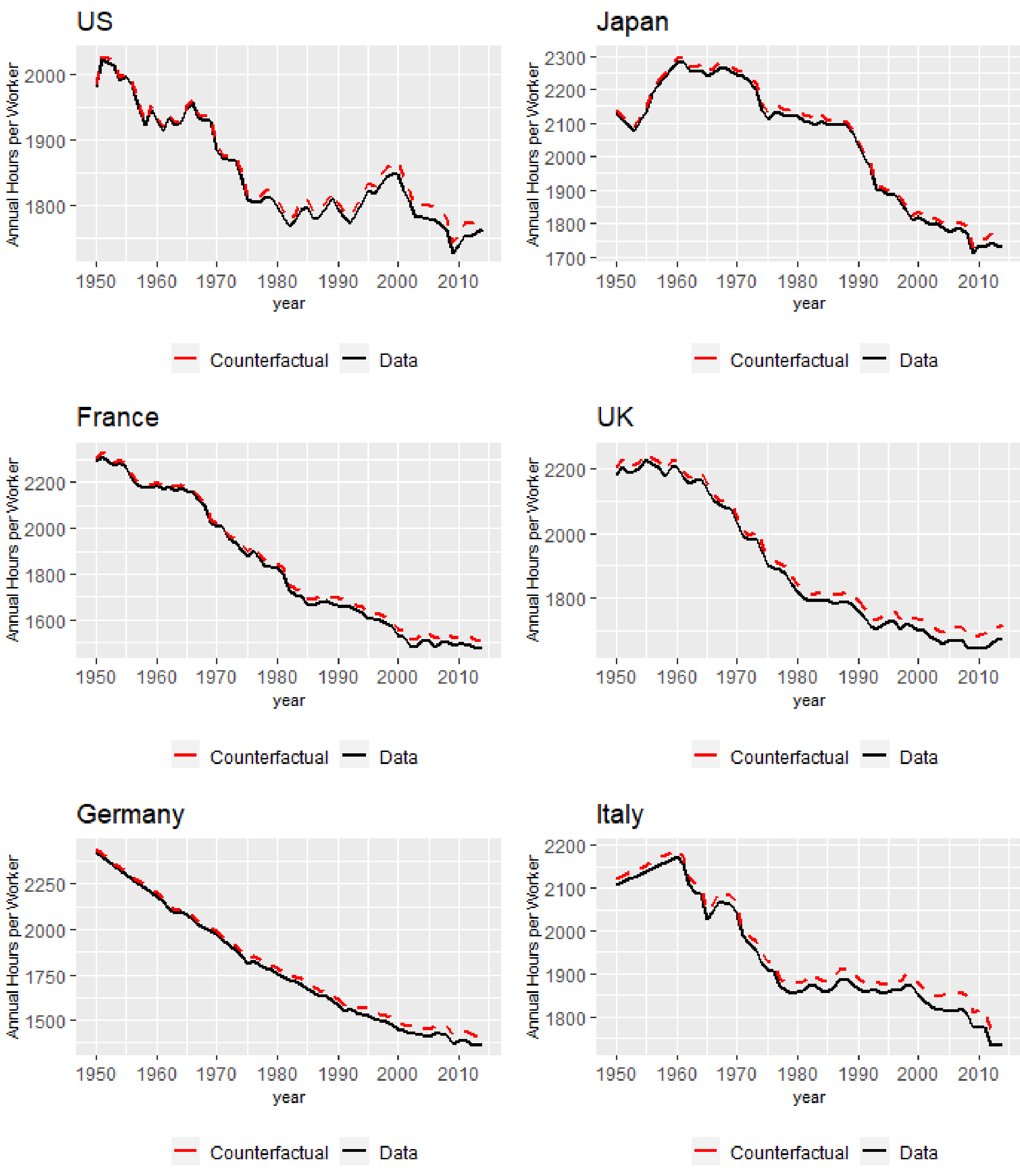
$$h_t^C = (\frac{1}{\pi_t})^{-\frac{\rho}{\theta}} \cdot h_t. \tag{23}$$

This series is based on the equilibrium number of hours worked (13). Hours h_t^C removes the impact of trade, and the evolution of h_t^C is driven by all factors other than trade, e.g. TFP, capital accumulation, government policies and preference shocks. In (23), I replace $\rho = -0.16$ and $\theta = 1$, as discussed in Section 5.3.[30] Due to data limitations, I focus only on a few OECD countries that have available data going back to 1950.

Figure 2 depicts the actual time series of hours per worker and the counterfactual. The difference between h_t^C and h_t is the number of leisure hours that trade is generating each year. As countries become more open, the data-based series falls with respect to the counterfactual series, thus showing the increasing leisure gains. For example, for the UK both series follow the same path in the 1950-80 period. Following the trade agreement with the European Common Market in the 1970s, the country became more open and, in response, British workers reduced their labor supply. Some cross-country differences are remarkable. Trade openness played a significant role in the stark decline of hours per worker in Switzerland, but a very limited role in Australia.

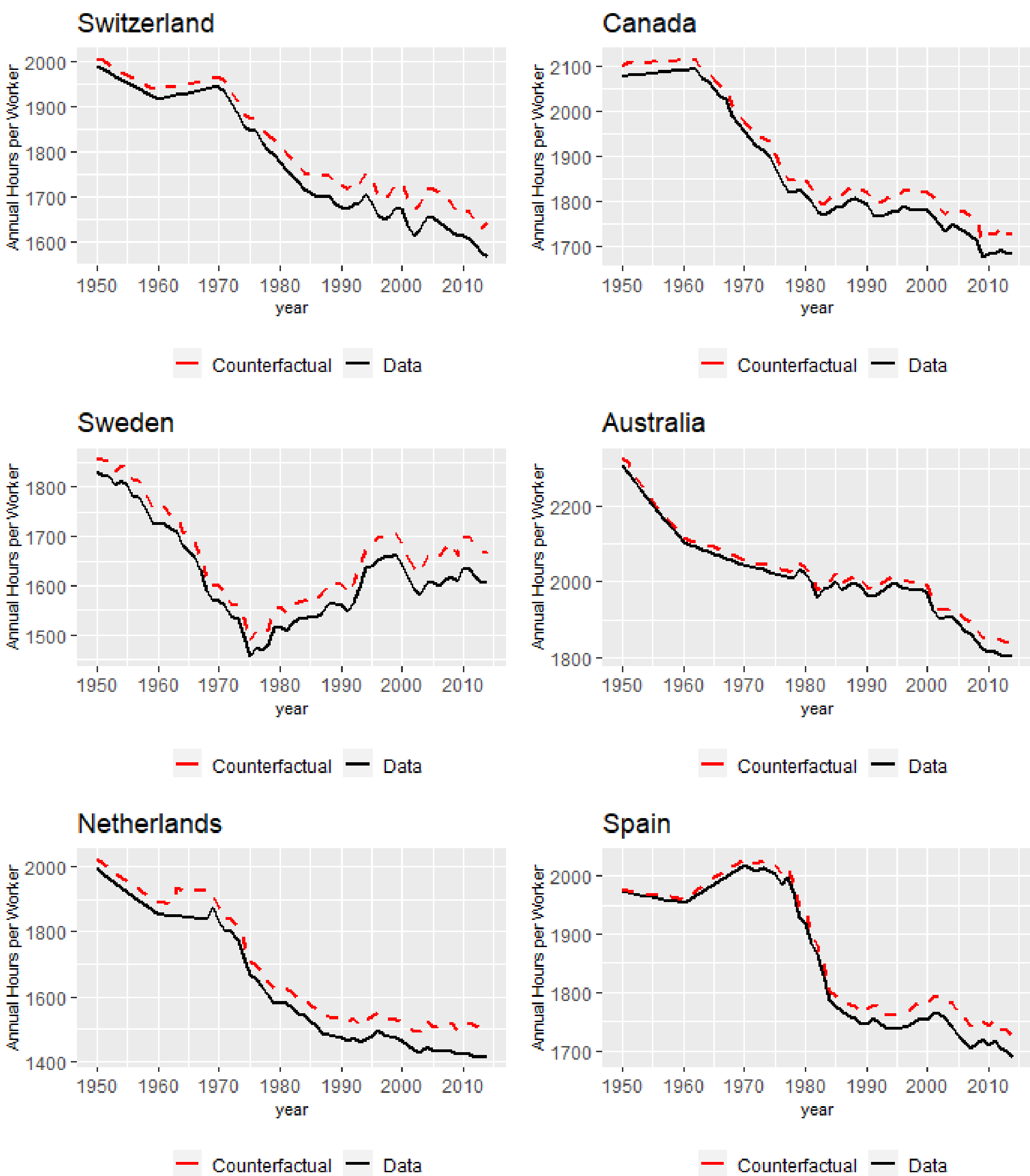
[30]The domestic trade share is based on PWT. To provide a conservative estimate of leisure gains, I inflate the denominator of the domestic trade share by a factor of 2.745 as in Bernard et al. (2003). This makes countries appear less open than using simply GDP as a denominator. This measure is comparable to using imports-to-gross spending, as employed in Costinot and Rodríguez-Clare (2014) to compute the welfare gains from trade. The corrected domestic share is comparable to that of World Input-Output Database I describe below for the years where both measures overlap.

Figure 2: Leisure gains from trade



Note: Black solid series shows data on annual hours per worker. Red dotted series shows annual hours per worker in autarky. The gap between the two series denotes the leisure gains from opening to trade. Source: PWT

Figure 2: Leisure gains from trade (cont'd)



Note: Black solid series shows data on annual hours per worker. Red dotted series shows annual hours per worker in autarky. The gap between the two series denotes the leisure gains from opening to trade.[a] Source: PWT

[a]Note: Counterfactual hours worked in the Netherlands in the 1960s follows a sudden jump in trade data.

Which countries benefited the most? Column 1 in Table 8 presents the number of leisure hours generated by trade openness and column 2 displays them in 8-hour working days. Using 2014 as a reference year, it compares hours worked from the counterfactual with those from the data. Workers in countries that opened their economies the most, such as the Netherlands and Switzerland, enjoy up to 91.1 annual hours (11.4 days per year) of leisure time. On the opposite end of the spectrum we find Australia, Japan and the US. These countries benefited less (around 3 days per year).

Table 8: Quantifying the leisure gains from trade

	(1)	(2)	(3)
	Annual leisure time per worker generated by trade		(1) as % of the total decline in hours per worker
Country	in hours	in days	between 1950-2014
Netherlands	91.1	11.4	10.7
Switzerland	76.6	9.6	14.0
Sweden	61.1	7.6	15.1
Germany	48.0	6.0	3.3
Canada	42.9	5.4	4.8
United Kingdom	40.3	5.0	4.1
Spain	36.1	4.5	10.9
Italy	34.5	4.3	5.8
Australia	33.4	4.2	3.1
France	32.4	4.1	2.3
Japan	22.9	2.9	4.1
United States	18.9	2.4	6.5

Note: Column 1 reports the annual number of leisure hours per worker generated by trade in 2014. It is calculated as the difference between the counterfactual number of hours per worker in autarky and the number of hours observed in the data. Column 2 shows the results in work days assuming a daily 8 hour shift. Column 3 calculates the weight of these hours over the total within-country decline of per worker hours between 1950 and 2014.

Column 3 depicts the number of leisure hours per worker caused by trade openness (column 1) divided by the total increase in leisure (decline in hours per worker) between 1950 and 2014. Trade played a relevant role in the decline in hours per worker. On average, trade openness explains about 6.8 percent of the total decline in hours per worked in these countries. However, its relevance varies widely, from 2.3 percent in France to 15.1 percent in Sweden. Among the countries considered, the leisure gains from trade were particularly sizable in Sweden, Switzerland, the Netherlands and Spain.

The leisure time generated by trade can also be seen from an inverse scope. If countries were to close their economies, this would lower income and it would be optimal for workers to supply more labor. Countries that are the most open have the most to lose if they were to close their economies today. As a second exercise, I explore this point further. Starting from current levels of labor supply, I compute how much leisure time workers would lose if countries were to completely close their economies and move to autarky ($\pi = 1$). This provides the upper bound of potential leisure loss. Based on (14), the following expression shows the percentage change in the number of hours per worker of moving from current levels of trade to autarky

$$\Delta\% h = 1 - \pi^{-\frac{\rho}{\theta}} \tag{24}$$

As in the previous exercise, we only need data on the domestic trade share and a value for the elasticity of hours to trade. The size of leisure gains, may also vary when considering potential extensions to the baseline model. To explore this point further, I calculate the leisure gains when my model is expanded to include including capital in production, intermediate inputs, and a margin of firm entry and exit, as discussed in Section 3. I calculate (24) for all these model extensions, where the elasticity of hours to trade is the one expressed in Table 1.

For the counterfactual calibrations I keep using $\rho = -0.16$ and $\theta = 1$. The parameters of the model's extension are standard. The capital share is $\alpha = 1/3$ and the labor share in the production of the composite good is $\lambda = 2/3$. The elasticity of substitution across product varieties σ is set to 6 as employed in Arkolakis et al. (2008). For the domestic trade share, I employ data from the World Input Output Database (WIOD) as in Adao et al. (2017), using 2014 as my reference year.[31]

Table 9 presents the magnitude of the leisure lost from moving to autarky. The first column shows the percentage increase in annual hours worked implied by a unilateral move to autarky. I find that for the median country, workers would find it optimal to supply 10.4% more hours to compensate for the income lost due to a trade shut down. Nonetheless, this increase varies widely across countries. Countries that are more open benefit from more leisure and would supply the most hours if they were to move to autarky.

Column 2 transforms these percentages into actual working days. It shows the difference between the autarky equilibrium and the observed number of hours per worker in 2014 (expressed in 8-hour working days). Given that the actual number of observed hours worked also varies due to other factors (culture, institutions, etc.), the same percentage increase in hours materializes into different number of days in different countries (e.g. see Finland and Greece). These days represent the magnitude of leisure that the average worker in each country would lose per year by moving autarky. The median household in the sample would increase its supply of hours by 10 percent, or 23 working days, to compensate for the income loss created by autarky.

Columns 3-8 replicate 1-2 across different extensions of the baseline model. The inclusion of capital and intermediate inputs in production boost the income gains from trade, leading to larger leisure gains. The inclusion of intermediate inputs has sizable impact on the leisure gains, of about 5.6 percentage points larger than the baseline. Finally, columns 7 and 8 present the leisure gains

[31] This version of the domestic trade share accounts for all goods and services imported by a country, reflecting the pay to foreign factor services. In other words, it provides the most accurate and commonly employed method to measure trade openness in counterfactual exercises. See Costinot and Rodríguez-Clare (2014).

when a margin of firm entry-and-exit is included in the model. The leisure gains are slightly smaller than in the baseline case. This is driven by a crowding-out effects the impact of trade openness. When the number of firms is a function of market size (labor supply), its decline reduces the number of firms in equilibrium. In turn, this reduces labor demand and wages, partially crowding out the leisure gains from trade. This degree of crowding out is small across all countries.

As a last exercise, I quantitatively assess the magnitude of the welfare (utility) gains from trade. I present the welfare loss of a counterfactual move from trade to autarky in 2014. This is the absolute value of the percentage change in utility that would be associated with moving to autarky in each country. The calculations are based on the welfare gains from trade (15). For the calibration I assume $\eta = 1.73$, $\varepsilon = 0.35$, which combined yield $\rho = -0.16$. These values for η and ε are akin to those employed by Heathcote et al. (2014). Regarding the trade elasticity, I employ $\theta = 1$ as previously discussed.

Table 10 presents the results. Column 1 displays the welfare (utility) gains from trade in my model when labor is inelastic. Column 2 shows the same results, but allowing an elastic labor supply in the model. The welfare gains are larger when labor supply is elastic. The difference between the two measures of welfare is heterogeneous across countries. As it is displayed in (15), the welfare gains from trade are non-linearly increasing in the degree of trade openness. Countries that are more open to trade, such as Ireland or Luxembourg, have larger welfare gains from trade driven by labor supply adjustments. For the median country, the additional gain in welfare by including an elastic labor supply (column 3) is 0.38 percentage points, while this value for the average country is 1 percentage point.

Table 9: Increase in annual hours per worker when moving to autarky

	(1) baseline	(2)	(3) with capital	(4)	(5) with inter. inputs	(6)	(7) with firm entry and exit	(8)
Country	in %	in days	in %	in days	in %	in days	in %	in days
Australia	5.4	12.2	5.7	12.9	8.0	18.1	5.3	11.9
Austria	13.1	26.6	13.8	28.0	19.0	38.6	12.7	25.9
Belgium	17.9	35.3	18.8	37.1	25.7	50.5	17.4	34.3
Bulgaria	14.8	30.3	15.5	31.9	21.3	43.8	14.3	29.5
Brazil	3.9	8.3	4.1	8.8	5.8	12.3	3.8	8.0
Canada	8.8	18.5	9.2	19.5	12.9	27.1	8.5	17.9
Switzerland	10.6	20.9	11.2	22.0	15.5	30.4	10.3	20.2
China	3.0	na	3.2	na	4.4	na	2.9	na
Cyprus	14.4	32.9	15.2	34.6	20.8	47.6	14.0	32.0
Czech Republic	16.3	36.0	17.1	37.9	23.4	51.8	15.8	35.0
Germany	10.1	17.4	10.7	18.3	14.8	25.4	9.8	16.9
Denmark	13.0	23.4	13.7	24.6	18.8	33.9	12.6	22.7
Spain	7.7	16.3	8.1	17.2	11.4	24.0	7.5	15.8
Estonia	18.3	42.4	19.2	44.6	26.1	60.7	17.7	41.3
Finland	10.0	20.5	10.5	21.6	14.6	30.0	9.7	19.9
France	8.0	14.7	8.4	15.5	11.7	21.6	7.8	14.3
United Kingdom	7.5	15.7	7.9	16.6	11.0	23.1	7.3	15.3
Greece	9.9	25.3	10.4	26.6	14.5	37.0	9.6	24.5
Croatia	12.5	na	13.2	na	18.2	na	12.2	na
Hungary	21.5	50.0	22.6	52.5	30.5	70.9	20.9	48.7
Indonesia	6.1	15.5	6.4	16.3	9.0	22.8	5.9	15.0
India	4.8	12.9	5.0	13.6	7.1	19.1	4.6	12.5
Ireland	26.5	60.2	27.7	63.1	36.9	84.1	25.8	58.6
Italy	6.7	14.5	7.0	15.3	9.8	21.3	6.5	14.0
Japan	5.2	11.2	5.5	11.8	7.7	16.6	5.0	10.9
Republic of Korea	9.0	23.8	9.4	25.1	13.1	34.9	8.7	23.1
Lithuania	20.2	46.3	21.2	48.6	28.7	65.9	19.7	45.1
Luxembourg	30.8	57.9	32.2	60.5	42.5	79.7	30.0	56.4
Latvia	12.6	30.6	13.3	32.2	18.3	44.4	12.2	29.7
Mexico	8.9	23.7	9.3	24.9	13.0	34.7	8.6	23.0
Malta	26.9	65.9	28.2	69.0	37.5	91.9	26.2	64.2
Netherlands	15.8	28.0	16.6	29.4	22.7	40.2	15.3	27.2
Norway	8.5	15.1	8.9	15.9	12.4	22.1	8.2	14.6
Poland	11.3	28.8	11.9	30.3	16.4	41.9	11.0	27.9
Portugal	10.4	24.1	10.9	25.4	15.2	35.2	10.1	23.4
Romania	10.2	23.1	10.7	24.3	14.9	33.8	9.9	22.4
Russian Federation	5.9	14.8	6.3	15.6	8.8	21.8	5.8	14.3
Slovakia	18.5	40.8	19.4	42.9	26.5	58.3	18.0	39.7
Slovenia	16.9	33.0	17.8	34.7	24.3	47.3	16.4	32.1
Sweden	10.9	21.9	11.4	23.0	15.9	31.9	10.6	21.2
Turkey	8.1	18.5	8.5	19.5	11.9	27.2	7.9	18.0
Taiwan	13.7	36.4	14.4	38.2	19.8	52.6	13.3	35.3
United States	3.9	8.6	4.1	9.0	5.8	12.7	3.8	8.3

Note: This table shows the percentage change in annual hours worked of moving from trade openness in 2014 to autarky. This percentage is expressed in work days assuming a daily 8 hour shift, by multiplying changes with actual hours per worker in each country. All calculations are based on the equation (24), where the exponent of the domestic trade share takes the form of different model extensions, as shown in Table 1. Calculations assume $\rho = -0.16$, $\theta = 1$, $\alpha = 1/3$, $\lambda = 2/3$ and $\sigma = 6$. Source: WIOD. na: not available

Table 10: Welfare loss from moving from trade to autarky

	(1)	(2)	(3)
	$\hat{W}$ expressed in percentages computed using:		
Country	inelastic labor	elastic labor	(2) - (1)
Australia	11.86	11.94	0.08
Austria	32.54	33.21	0.67
Belgium	48.84	50.38	1.55
Bulgaria	37.89	38.80	0.91
Brazil	8.28	8.32	0.04
Canada	20.26	20.51	0.25
Switzerland	25.38	25.78	0.40
China	6.29	6.31	0.02
Cyprus	36.77	37.62	0.86
Czech Republic	42.94	44.12	1.18
Germany	23.99	24.35	0.35
Denmark	32.31	32.97	0.66
Spain	17.54	17.73	0.19
Estonia	49.99	51.62	1.62
Finland	23.58	23.93	0.34
France	18.22	18.42	0.20
United Kingdom	16.99	17.17	0.18
Greece	23.33	23.67	0.34
Croatia	30.93	31.53	0.60
Hungary	62.81	65.43	2.62
Indonesia	13.50	13.61	0.11
India	10.30	10.36	0.06
Ireland	85.53	90.57	5.04
Italy	14.91	15.04	0.13
Japan	11.33	11.40	0.08
Republic of Korea	20.79	21.06	0.26
Lithuania	57.50	59.68	2.18
Luxembourg	109.77	118.37	8.59
Latvia	31.14	31.75	0.61
Mexico	20.51	20.77	0.26
Malta	87.67	92.98	5.31
Netherlands	41.17	42.25	1.08
Norway	19.44	19.67	0.23
Poland	27.24	27.70	0.46
Portugal	24.66	25.04	0.38
Romania	24.10	24.46	0.36
Russian Federation	13.12	13.23	0.10
Slovakia	50.96	52.65	1.69
Slovenia	45.12	46.43	1.31
Sweden	26.03	26.45	0.42
Turkey	18.49	18.70	0.21
Taiwan	34.48	35.23	0.75
United States	8.29	8.33	0.04

Note: Columns 1 and 2 show the percentage change in utility loss of moving from trade in 2014 to autarky for my model with inelastic and elastic labor supply, respectively. Column 3 show the percentage point differences among the two welfare measures. All calculations are based on equation (15), assuming $\eta = 1.73$ and $\varepsilon = 0.35$, (which implies $\rho = -0.16$), and $\theta = 1$. Source: WIOD.

7 Conclusions

In this paper I show that trade leads to a decline in labor supply and an increase in leisure through income effects. Using an extension of a standard multicountry Ricardian trade model, I derive an elasticity linking the number of hours worked and the domestic trade share. I evaluate the predictions of my model by estimating structural equations in a country-year panel. By employing a time-varying geographic instrument, I am able to identify exogenous variation in trade openness and estimate the elasticity of hours to trade. My empirical results show that a one percentage point increase in the domestic trade share causes a 0.51 percent increase in hours per worker. Combining my estimated coefficients, I recover the underlying parameters of the elasticity of hours-to-trade: the elasticity of hours to real wages (uncompensated elasticity) and the trade elasticity, which are then used to quantify the leisure gains from trade. I back out an elasticity of hours to wages of -0.16, thus showing that income effects outweigh substitution effects.

In the spirit of Arkolakis et al. (2012), I show that the quantification of the leisure gains from trade requires only three sufficient statistics: the domestic trade share, the elasticity of hours to wages and the trade elasticity. Across countries, I quantify that the increase in trade between 1950 and 2014 has generated between 19 and 91 hours of additional leisure time per worker per year. The leisure time generated by trade represents around 7 percent of the total decline in hours per worker over this period. I then estimate that if countries would move to autarky, the median household would increase their supply of hours by around 10 percent. But, this magnitude may three-fold for countries that are largely open to trade. Finally, I show that the increase in leisure is consistent with an increase in workers' welfare. The leisure gains from trade are, on average, up to one percent larger when labor supply is elastic.

In this paper, I find that trade leads to leisure gains for the average household. However, the paper remain silent on how the household would allocate this extra leisure across its members. In a follow-up study, Nicolas Depetris-Chauvin and I look into this question and study the heterogeneous response of hours to trade across workers of different age, gender and education (Depetris-Chauvin and Velasquez, 2024). We find that, within the household, most of the leisure is allocated to lower-income workers, mainly the young and older workers. Female and less-educated workers also tend to benift relatively more.

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Online Appendix

A Preferences consistent with a balanced growth path

Here I discuss how the utility function (1) is consistent with a balanced growth path. For a more in-depth discussion, and a more generalized version of these preferences, please refer to Boppart and Krusell (2020).

For utility (1) to be consistent with a balanced growth path, consumption, real wages and hours worked must satisfy the budget constraint and the labor supply equation in all time periods. For this, we need consumption, hours worked and real wages to grow at a constant rate. For the budget constraint this means that: $\widehat{c} = \frac{\hat{w}}{P}\widehat{h}$, where hat denotes changes between two consecutive periods. Now, assume $\widehat{\frac{w}{P}}$ grows at a constant and exogenous rate γ (for example following improvements in total factor productivity). Then, according to our labor supply (4), hours worked will grow —or decline—at rate $\gamma_H = \gamma^{\rho}$. Using the budget constraint, consumption will grow at rate $\gamma_C = \gamma^{1+\rho}$.

If $\rho < 0$, then an increase in real wages of one percent would lead to a decline in hours supplied of ρ percent. Then, consumption will grow at a rate of $1+\rho$ percent. Consumption will grow over time, but not at a one-to-one pace with productivity growth. If $\rho = 0$ we are back in the standard case. Consumption in the utility function would be $\log(C_t)$ and hours would be trend-less. An increase in real wages γ would lead to an increase in consumption of the same amount $\gamma_C = \gamma$ and generate no change on labor supply.

This utility function is consistent with the Euler equation. The interest rate in an intertemporal setting is constant. To show this we extend the budget constraint and allow the representative household to make savings-consumption decisions in order to smooth consumption over time. Assume there is a risk-less asset with unlimited supply. The interest rate of this asset is $(1 + r_t)$. The Euler condition is

$$\frac{u_C(C_t, H_t)}{u_C(C_{t+1}, H_{t+1})} = (1 + r_t)\beta,$$

with β a constant discount rate. Replacing our functional form yields $(1+r_t) = \frac{\gamma^{(1-\rho)\eta}}{\beta}$. The interest rate is stationary (it is a function of all constants). This supports the case that preferences such as (1) are consistent with a balanced growth path.

In Section 5.3, I estimate ρ to be -0.16. Then, if real wages grow at 2 percent we would have an annual decline in hours worked of 0.32 percent.[32] Consumption would grow at 1.68 percent per year and the interest rate would be constant at 5 percent.[33] This shows that the utility function (1), can be consistent with a balanced growth path beyond the special case of $\rho = 0$.

[32] $1.02^{-0.16} = 0.9968$

[33] Assuming $\eta = 1.1$ and a discount rate of $\beta = 0.97$

B Proof of existence and uniqueness of the model's equilibrium

I show the necessary conditions for the model's equilibrium to be unique. The proof follows the same steps as in Alvarez and Lucas (2007) by finding the zeros of an excess demand function.

Starting from the trade share equation, I define the excess demand function $Z(\mathbf{w})$:

$$\sum_n \pi_{in} w_n H_n = w_i H_i$$

$$Z(\mathbf{w}) = \frac{1}{w_i}\left[\sum_n \pi_{in} w_n H_n - w_i H_i\right] = 0$$

Replacing with the labor supply, trade share and price index equations yields

$$Z(\mathbf{w}) = \frac{1}{w_i}\left[\sum_n \left(d_{in} w_n\right)^{-\theta} T_n w_n^{\frac{1+\varepsilon}{1+\varepsilon\eta}} \left(\sum_i T_i \left(d_{ni} w_i\right)^{-\theta}\right)^{\frac{\varepsilon(1-\eta)-\theta(1+\varepsilon\eta)}{(\eta\varepsilon+1)\theta}} \right.$$
$$\left. - w_i^{\frac{1+\varepsilon}{1+\varepsilon\eta}} \left(\sum_n T_n \left(d_{in} w_n\right)^{-\theta}\right)^{\frac{\varepsilon(1-\eta)}{(\eta\varepsilon+1)\theta}} \right]$$

To prove uniqueness we verify that $Z(\mathbf{w})$ has the following properties. It is continuous, homogeneous of degree zero and satisfies Walras' Law.

- $Z(\mathbf{w})$ is homogeneous of degree zero

$$Z(\mathbf{w}t) = \frac{1}{tw_i}\left[\sum_n \left(d_{in} w_n\right)^{-\theta} t^{-\theta} T_n w_n^{\frac{1+\varepsilon}{1+\varepsilon\eta}} t^{\frac{1+\varepsilon}{1+\varepsilon\eta}} t^{\frac{-\varepsilon(1-\eta)+\theta(1+\varepsilon\eta)}{(\eta\varepsilon+1)}} \left(\sum_i T_i \left(d_{ni} w_i\right)^{-\theta}\right)^{\frac{\varepsilon(1-\eta)-\theta(1+\varepsilon\eta)}{(\eta\varepsilon+1)\theta}} \right.$$
$$\left. - w_i^{\frac{1+\varepsilon}{1+\varepsilon\eta}} t^{\frac{1+\varepsilon}{1+\varepsilon\eta}} t^{-\frac{\varepsilon(1-\eta)}{(\eta\varepsilon+1)}} \left(\sum_n T_n \left(d_{in} w_n\right)^{-\theta}\right)^{\frac{\varepsilon(1-\eta)}{(\eta\varepsilon+1)\theta}} \right]$$

$$\frac{1}{tw_i}\left[t\sum_n \left(d_{in} w_n\right)^{-\theta} T_n w_n^{\frac{1+\varepsilon}{1+\varepsilon\eta}} \left(\sum_i T_i \left(d_{ni} w_i\right)^{-\theta}\right)^{\frac{\varepsilon(1-\eta)-\theta(1+\varepsilon\eta)}{(\eta\varepsilon+1)\theta}} \right.$$
$$\left. - tw_i^{\frac{1+\varepsilon}{1+\varepsilon\eta}} \left(\sum_n T_n \left(d_{in} w_n\right)^{-\theta}\right)^{\frac{\varepsilon(1-\eta)}{(\eta\varepsilon+1)\theta}} \right] = t^0 Z(\mathbf{w})$$

- $Z(\mathbf{w})$ satisfies Walras' Law

$$Z(\mathbf{w}) * \mathbf{w} = 0$$

$$Z(\mathbf{w}) w_i = \sum_n \pi_{in} w_n H_n - w_i H_i$$

summing over i

$$\sum_i \left[\sum_n \pi_{in} w_n H_n - w_i H_i \right]$$

$$\sum_i \sum_n \pi_{in} w_n H_n - \sum_i w_i H_i = \sum_i w_i H_i - \sum_i w_i H_i = 0$$

In addition the model needs to satisfy the gross substitutes property: $\frac{\partial Z(w_i)}{\partial w_k} > 0$

$$\frac{\partial Z(w_i)}{\partial w_k} = \left(\frac{1+\varepsilon}{1+\varepsilon\eta} - \theta \right) w_k^{\frac{1+\varepsilon}{1+\varepsilon\eta} - \theta - 1} \left(\sum_i T_i \left(d_{ni} w_i \right)^{-\theta} \right)^{\frac{\varepsilon(1-\eta) - \theta(1+\varepsilon\eta)}{(\eta\varepsilon+1)\theta}}$$

$$-w_k^{\frac{1+\varepsilon}{1+\varepsilon\eta} - \theta} \frac{\varepsilon(1-\eta) - \theta(1+\varepsilon\eta)}{(\eta\varepsilon+1)\theta} \left(\sum_i T_i \left(d_{ni} w_i \right)^{-\theta} \right)^{\frac{\varepsilon(1-\eta) - \theta(1+\varepsilon\eta)}{(\eta\varepsilon+1)\theta} - 1} \left(\theta T_k d_{ik}^{-\theta} w_k^{-(\theta+1)} \right)$$

$$+\theta T_k d_{ik}^{-\theta} w_k^{-(\theta+1)} \frac{(\eta-1)\epsilon}{\theta + \eta\theta\epsilon} \left(\sum_n T_n \left(d_{in} w_n \right)^{-\theta} \right)^{\frac{\epsilon - \eta\epsilon}{\theta + \eta\theta\epsilon} - 1} w_i^{\frac{1+\varepsilon}{1+\varepsilon\eta}}$$

A necessary condition requires $\varepsilon(1-\eta) - \theta(1+\varepsilon\eta) < 0$, which turns into $\frac{\varepsilon(1-\eta)}{(1+\varepsilon\eta)} < \theta$, which can also be expressed as $-\rho < \theta$. In other words, the trade elasticity needs to be larger than the magnitude of the elasticity of hours to wages. Finally, existence and uniqueness is proven by invoking propositions 17.B.2, 17.C.1 and 17.F.3 from Mas-Colell et al. (1995).

C Extensions to the model

C.1 Including capital in the model

I extend the model to include physical capital, as in Alvarez and Lucas (2007) and Waugh (2010). This extension provides a link between hours worked and the stock of physical capital at the country level. The omission of capital in the main model does not modify its main takeaways nor the empirical findings.

The budget constraint with capital. Households earn income from labor and capital and use this income to consume and save. Rents from capital can be expressed as a function of wages, hours and capital stock given the firms' technology. The following steps allow me to write the budget constraint as a function of labor income only. First, define total real income Y_i in country i as

$$Y_i = \frac{w_i}{P_i} H_i + \frac{r_i}{P_i} K_i, \tag{25}$$

where r_i is the rental rate of capital, and K_i is the stock of physical capital.

Assuming perfect competition in factor markets and linear technology in production (discussed below), I replace r_i with the following expression derived from the first order conditions of cost minimization

$$r_i = \frac{\alpha}{1-\alpha} w_i H_i K_i^{-1}. \tag{26}$$

Replacing this expression in (25), real income can be expressed as $Y_i = (1-\alpha)^{-1} \frac{w_i}{P_i} H_i$, where α is the capital share.

My model assumes that all countries are on a balanced growth path (i.e. all variables grow at a constant rate). Therefore, the savings rate is fixed. This allows me to define the amount of income destined for consumption as a fixed share. Aggregate consumption is $C_i = \tilde{c} Y_i$, with $\tilde{c}$ being a constant. Using these substitutions I can express the budget constraint as a function of consumption and labor income as

$$C_i = \kappa \frac{w_i}{P_i} H_i, \tag{27}$$

where κ is a collection of constants. For simplicity I am going to ignore κ in the coming steps. The representative household's problem is to choose the optimal amounts of consumption and leisure. The labor supply function (4) is not affected by the inclusion of capital.

Firms employ linear technology and take output and factor prices as given. The profit maximization problem of firms is

$$\max_{H_i(u), K_i(u)} p_i^p(u) z_i(u) K_i(u)^\alpha H_i(u)^{(1-\alpha)} - w_i H_i(u) - r_i K_i(u).$$

Equilibrium. The equilibrium of the model remains isomorphic to the one explained in the main manuscript. Besides labor supply, the three other equations that characterize the equilibrium are the price index

$$P_i \equiv \gamma \Phi_i^{-1/\theta} \qquad \text{and} \qquad \Phi_i \equiv \sum_{n=1}^{N} T_n \left(r_n^\alpha w_n^{1-\alpha} d_{in} \right)^{-\theta}, \tag{28}$$

the trade share

$$\pi_{in} \equiv \frac{X_{in}}{X_i} = \frac{T_n (r_n^\alpha w_n^{1-\alpha} d_{in})^{-\theta}}{\Phi_i}, \tag{29}$$

and trade balance

$$w_i H_i + r_i K_i = \sum_{n=1}^{N} \pi_{in} (w_n H_n + r_n K_n). \tag{30}$$

Accounting for hours worked. Now, following the same steps described above, the new expression for the real wage is

$$\frac{w_i}{P_i} = (1-\alpha) \pi_{ii}^{-1/\theta} T_i^{1/\theta} (\frac{K_i}{H_i})^\alpha. \tag{31}$$

On the right-hand side of (31) we have an expression that resembles the marginal product of labor of an aggregate Cobb-Douglas production function. The real wage equation (31) can also be interpreted as a labor demand equation. Rearranging, we can express the total number of labor hours demanded in country i as a function of T_i, π_{ii}, K_i and $\frac{w_i}{P_i}$.

Equating labor demand (31) with the labor supply (4) and solving for hours yields the equilibrium of hours worked at the country level

$$H_i = \tilde{\psi}_i \pi_{ii}^{\frac{-\rho}{(1+\alpha\rho)\theta}} T_i^{\frac{\rho}{(1+\alpha\rho)\theta}} K_i^{\frac{\alpha\rho}{(1+\alpha\rho)}}. \tag{32}$$

This expression shows that the equilibrium number of hours worked also depends on the stock of capital. If income effects dominate substitution effects, we should observe fewer hours in countries with more stock of capital. However, the trade elasticity does not play a role in this case, showing that the impact of capital on hours worked is independent from the trade channel.

In addition, note that now the sensitivity of hours worked to the domestic trade share in now multiplied by $1/(1+\alpha\rho)$. This term captures the weight of labor in the production function and on its income share. The lower α, the more important labor is in production yielding a larger income effect and reduction in labor supply. In the limit, if $\alpha = 0$, we obtain the same model as described in the main text without capital.

Finally, solving for the equilibrium of aggregate income yields

$$Y_i = \underbrace{\tilde{\psi}_i \pi_{ii}^{\frac{-(1+\rho)}{(1+\alpha\rho)\theta}} T_i^{\frac{1+\rho}{(1+\alpha\rho)\theta}}}_{\equiv A_i} K_i^{-\frac{\alpha(1+\rho)}{(1+\alpha\rho)}}. \tag{33}$$

This equation expresses the effects of real income on exogenous variables. This is a more general expression than Eaton and Kortum (2002) and Waugh (2010) because it incorporates labor supply adjustments to changes in real wages. Trade raises wages and income, but the decline in labor supply crowds-in this effect. Note that as long as $\rho < 0$, real GDP and, by consequence, consumption are strictly smaller than the case with inelastic labor supply.

We can think of the structural link between the domestic trade share and income in the classic income accounting setting (Caselli, 2005; Waugh, 2010), where A_i in (33) is total factor productivity in a closed economy. Therefore, changes in the domestic trade share can be understood as changes in TFP. This interpretation is also valid for the equilibrium of hours worked in (32). Opening to trade has the same effect on hours as becoming more efficient.

Note that the main takeaways of the model without capital are not affected by its omission. The inclusion of capital only modifies slightly the mapping between the econometric estimates and the parameters of the model. In (32), the term $1/(1+\alpha\rho)$ which multiplies the elasticity of hours to the domestic trade share in the original version of the model is expected to be close to one (given that the model assumes $|\rho| < 1$ and assuming $\alpha = 1/3$). In Appendix E, I include capital as a control in the baseline regressions, and show that the coefficient of the domestic trade share on hours remains broadly unchanged and significant.

C.2 Including multiple sectors and intermediate inputs

I extend the model to include multiple sectors and intermediate inputs as in Costinot et al. (2012) and Alvarez and Lucas (2007). Both extensions strengthen the income effects from trade, and consequentially, on hours.

Multiple sectors. Assume there is a continuum of sectors indexed by $s = 1, \ldots, S$. Within each sectors there is a continuum of fixed varieties produced. The technology remains the same as in the main model, but now each sector has an idiosyncratic efficiency level T_i^s withdrawn from an independent Fréchet probability distribution. The trade elasticity θ is assumed to remain identical across industries and countries. The main feature of multiple sectors is that the heterogeneous efficiency across sectors shapes the specialization of countries in terms of consumption and trade (CDK).

The representative household has a two-tier utility function. The upper tier of this utility function is Cobb-Douglas across sectors, with consumption shares $0 \leq \omega^s \leq 1$, and a lower tier Dixit-Stiglitz across varieties with elasticity of substitution $\sigma > 1$. Then, the price index in country i is $P_i = \prod_{s=1}^{S}(P_i^s)^{\omega^s}$, where P_i^s is the aggregate Dixit-Stiglitz consumer price index defined in (6).

Solving the model following the same steps as above yields

$$\frac{w_i}{P_i} = \prod_{s=1}^{S}(T_i^s)^{\frac{\omega_i^s}{\theta}}(\pi_{ii}^s)^{-\frac{\omega_i^s}{\theta}}$$

where $0 \leq \pi_{ii}^s \leq 1$ is the share of expenditure used to purchase domestic goods in sector s. This expression reveals that real wages are larger with multiple sectors.[34] In turn, the equilibrium number of hours is

$$H_i = \prod_{s=1}^{S}(\pi_{ii}^s)^{-\frac{\rho\omega_i^s}{\theta}}(T_i^s)^{\frac{\rho\omega_i^s}{\theta}}$$

and changes in hours become

$$\widehat{H}_i = \prod_{s=1}^{S}(\widehat{\pi}_{ii}^s)^{-\frac{\rho\omega_i^s}{\theta}}$$

which is a generalization of equation (11). Now the income effects from trade are weighted depending on the household's preference distribution over the sectors (ω_i^s).

Intermediate inputs. Let's assume that there is a composite good that can be used as an input to produce other goods or, alternatively, consumed. This composite good is assumed to be produced with CES production technology (where all inputs are gross substitutes). Then, each intermediate good is produced from this composite good and labor with Cobb-Douglas technology. Define the

[34] An alternative to visualize this is that total expenditure is $P_iC_i = \prod_{s=1}^{S}(P_i^s)^{\omega^s}(C_i^s)^{\omega^s} = \prod_{s=1}^{S}(P_i^sC_i^s)^{\omega^s} = \prod_{s=1}^{S}(P_i^s\frac{\prod_{s=1}^{S}w_iH_i}{P_i^s})^{\omega^s}$ which is equal to $\bar{\omega}w_iH_i$, with $\bar{\omega} = \prod_{s=1}^{S}(\omega^s)^{\omega s} < 1$. Then labor income is strictly larger when there are multiple sectors $w_iH_i = \frac{PiC_i}{\bar{\omega}}$ compared to the single sector case.

labor share in the production of this composite good as λ, then the price of the intermediate good is $c_i = w_i^{\lambda} P_i^{1-\lambda}$

Then it follows that equation (9) becomes

$$\pi_{ii} = T_i (\frac{c_i}{P_i})^{-\theta}$$

and

$$c_i = T_i^{\frac{1}{\theta}} \pi_{ii}^{-\frac{1}{\theta}} P_i$$

substituting c_i

$$w_i^{\lambda} P_i^{1-\lambda} = T_i^{\frac{1}{\theta}} \pi_{ii}^{-\frac{1}{\theta}} P_i$$

which yields

$$\frac{w_i}{P_i} = T_i^{\frac{1}{\lambda\theta}} \pi_{ii}^{-\frac{1}{\lambda\theta}}$$

This equation shows that the income gains from trade are larger when the composite good commands a larger share of intermediate goods (high $1-\lambda$). This creates an input-output loop from the use of intermediate inputs across countries. Finally, the link between hours and trade becomes

$$H_i = \pi_{ii}^{-\frac{\rho}{\lambda\theta}} T_i^{\frac{\rho}{\lambda\theta}}$$

and

$$\widehat{H}_i = \widehat{\pi}_{ii}^{-\frac{\rho}{\lambda\theta}}$$

A lower labor share λ in the production of intermediate inputs amplifies the income gains from trade and boosts the leisure gains.

C.3 Adding a firm entry and exit margin

This subsection displays the effects that a firm margin adjustment could have on the equilibrium of hours. With endogenous firm entry, the equilibrium number of firms in any country is a function of its national labor supply. Thus, when labor supply declines following a trade liberalization, some number of firms exit the market reducing the income gains. The link between trade and hours remains isomorphic to equation (11), but this margin reduces the elasticity between trade and hours. The main features of the model remain intact except for production, which is now conformed by entry and exit of firms in the spirit of Melitz (2003) with monopolistic competition. For the following steps, I follow Arkolakis et al. (2008) (please consult for a more detailed discussion and derivations).

In my model it is assumed that there is a fixed number of varieties, and a continuum of perfectly competitive firms producing them. Instead, now I assume that each firm produces a differentiated good (with the household deriving utility from variety consumption), and that firms have heterogeneous potential productivity ϕ to produce.

The demand of a specific firm with productivity ϕ from country n from consumers in i is

$$x_{in}(\phi) = \frac{(p_{in}(\phi))^{-\sigma}}{P_i^{1-\sigma}} w_i H_i$$

with σ being the elasticity of substitution across varieties. The price index then is defined as

$$P_i^{1-\sigma} = \sum_n \int_0^{+\infty} p_{in}(\phi)^{1-\sigma} M_{in} \mu_{in}(\phi) d\phi \tag{34}$$

where M_{in} is the measure of firms exporting goods to i and $\mu_{in}(\phi)$ the distribution of productivities of country n conditional on selling to i.

Each firm is expected to pay a bilateral fixed entry cost f_{in} and transportation costs d_{in} to sell in a specific foreign country. Both costs are assumed to be measured in terms of foreign labor. Profit maximization of a potential firm in n selling to i is

$$\max_{p_{in}} \left\{ \frac{p_{in}^{1-\sigma}}{P_i^{1-\sigma}} w_i H_i - w_i H_i d_{in} \frac{p_{in}^{1-\sigma} w_n}{P_i^{1-\sigma} \phi} - w_i f_{in}, 0 \right\}$$

The first order condition implies that

$$p_{in} = \frac{\sigma}{\sigma - 1} \frac{w_n}{\phi} d_{in}$$

To operate, firms exporting from n to i should have a ϕ level of at least

$$(\phi_{in}^*)^{\sigma-1} = \frac{f_{in}}{(\frac{\sigma}{\sigma-1} d_{in} w_n)^{1-\sigma} \frac{1}{\sigma} \frac{H_i}{P_i^{1-\sigma}}} \tag{35}$$

Firm entry. It is assumed that firms must pay a fixed cost f_e to draw a productivity realization. These realizations come from a Pareto distribution with shape parameter $\theta > \sigma - 1$, with C.D.F. $G(\phi, b_i) = 1 - \frac{b_i^\theta}{\phi_i^\theta}$, where b_i is a technology parameter and the support of the C.D.F is $[b_i, +\infty)$. The parameter θ is the trade elasticity as in the main model and shapes the degree of comparative advantage. The assumptions of the technology in production imply that $\phi_{in}^* > \phi_{ii}^* > b_i, \quad \forall i, n, \quad i \neq n$. In other words, firms with $\phi < \phi_{ii}^*$ will not operate and only the most productive ones will export.

The labor market clearing and profit maximizing conditions are used to solve for the equilibrium number of firms and wages. The labor market clearing condition states that aggregate labor hours should be equal to the number of hours employed in production and the fixed costs of operation and entry. The second condition states that expected profits must equal the fixed entry costs. Using these conditions (see Arkolakis et al. (2008) for the derivations), the equilibrium number of firms producing in country i is

$$N_i = \frac{(\sigma - 1) b_i^\theta / (\phi_{ii}^*)^\theta}{\theta \sigma f_e} H_i \tag{36}$$

which is a function of H_i. This expression shows that a decline in labor hours would reduce the equilibrium number of firms in the economy.

Total sales from n to i then become

$$X_{in} = (\frac{\phi^*_{nn}}{\phi^*_{in}})^\theta N_n w_i f_{in} \frac{\sigma\theta}{\theta - \sigma + 1}$$

Using this expression combined with the number of firms (36) yields the trade share

$$\pi_{in} = \frac{H_n b_n^\theta (d_{in} w_n)^{-\theta} f_{in}^{\frac{1-\theta}{(\sigma-1)}}}{\sum_{n=1}^N H_n b_n^\theta (d_{in} w_n)^{-\theta} f_{in}^{\frac{1-\theta}{(\sigma-1)}}} \tag{37}$$

which is isomorphic to the trade share in my model (equation 7), but now it depends on market size.

Finally, combining the operating productivity cutoff (35) with the trade share, the real wage can be expressed as

$$\frac{w_i}{P_i} = \pi_{ii}^{-\frac{1}{\theta}} H_i^{\frac{1}{\sigma-1}} \left(\frac{b_i^\theta f_{ii}^{1-\theta/\sigma-1}}{f_e(\frac{\sigma}{\sigma-1})^\theta \sigma^{\theta/(\sigma-1)}} \frac{\sigma-1}{\theta-\sigma+1} \right)^{1/\theta}$$

which, by substituting $H_i = \frac{w_i}{P_i}^{\frac{(1-\eta)\varepsilon}{(1+\varepsilon\eta)}}$ and rearranging becomes

$$\frac{w_i}{P_i} = \pi_{ii}^{-\frac{\sigma-1}{(\sigma-1-\rho)\theta}} \tilde{T}_i^{\frac{\sigma-1}{(\sigma-1-\rho)\theta}} \tag{38}$$

The real wage now includes the effect of labor supply on the number of firms present in the country. The coefficient $-\frac{\sigma-1}{(\sigma-1-\rho)\theta} < 0$ can also be expressed as $-\frac{(\sigma-1)(1+\eta\varepsilon)}{(\sigma(1+\eta\varepsilon)-(1+\varepsilon))\theta}$. Note that if $\rho = 0$, then the link between real wages and trade only depends on θ.

$\tilde{T}_i$ is a combination of exogenous fixed costs and constants, $\tilde{T}_i = \frac{b_i^\theta f_{ii}^{1-\theta/\sigma-1}}{f_e(\frac{\sigma}{\sigma-1})^\theta \sigma^{\theta/(\sigma-1)}} \frac{\sigma-1}{\theta-\sigma+1}$. This term plays the same role as the efficiency level T_i in my model.

Finally, the link between hours and trade becomes

$$H_i = \pi_{ii}^{-\frac{(\sigma-1)\rho}{(\sigma-1-\rho)\theta}} \tilde{T}_i^{\frac{(\sigma-1)\rho}{(\sigma-1-\rho)\theta}} \tag{39}$$

which is isomorphic to equation (11). As in the main model, more trade openness (lower π_{ii}) leads to more hours worked. However, this effect is attenuated by firm exit and the loss in varieties. Compared to (11) the elasticity of trade to hours is multiplied by $\frac{\sigma-1}{\sigma-1-\rho}$ which is smaller than one if the representative household has preferences with dominating income effects. In the limit, the easier for the household to substitute varieties, higher σ, the smaller the impact of this channel would be on the equilibrium of hours.

D Proof of equivalent welfare variation from increasing trade costs

I begin by defining the expenditure function as:

$$e_i(P_i, u_i) = \min_{\{c_{in}\}} \{\sum_n p_{in} c_{in} \| u(\{c_{in}\}) \geq U\}$$

which means aggregate expenditure in country i becomes $e_i(P_i, u_i) = P_i C_i$. It depends on the aggregate price index and consumption basket. Then, I back out consumption as a function of a fixed level of utility u', in a counterfactual equilibrium with higher trade costs (variables with $'$ refer to those in a scenario with higher trade costs) using the model's preferences:

$$\frac{C_i^{1-\eta}}{1-\eta} - \frac{H_i^{1+\frac{1}{\varepsilon}}}{1+\frac{1}{\varepsilon}} = u_i'$$

Rearranging becomes:

$$C(u_i') = \left[(1-\eta)(u_i' + \frac{H_i^{1+\frac{1}{\varepsilon}}}{1+\frac{1}{\varepsilon}})\right]^{\frac{1}{1-\eta}}$$

Then, substituting this expression into the expenditure one:

$$e(P_i, u_i') = \left[(1-\eta)(u_i' + \frac{H_i^{1+\frac{1}{\varepsilon}}}{1+\frac{1}{\varepsilon}})\right]^{\frac{1}{1-\eta}} P_i$$

The welfare gains from trade $\widehat{W}_i$ are defined as:

$$\widehat{W}_i = \frac{e(P_i, u_i') - e(P_i, u_i)}{e(P_i, u_i)} = \frac{e(P_i, u_i') - w_i H_i}{w_i H_i} = \frac{e(P_i, u_i')}{w_i H_i} - 1$$

$$\widehat{W}_i = \frac{1}{w_i H_i} \left[(1-\eta)(u_i' + \frac{H_i^{1+\frac{1}{\varepsilon}}}{1+\frac{1}{\varepsilon}})\right]^{\frac{1}{1-\eta}} P_i - 1$$

Replacing u_i'

$$\widehat{W}_i = \frac{1}{w_i H_i} \left[(1-\eta)(\frac{C_i'^{1-\eta}}{1-\eta} - \frac{H_i'^{1+\frac{1}{\varepsilon}}}{1+\frac{1}{\varepsilon}} + \frac{H_i^{1+\frac{1}{\varepsilon}}}{1+\frac{1}{\varepsilon}})\right]^{\frac{1}{1-\eta}} P_i - 1$$

Substituting $C_i' = w_i' H_i' / P_i'$ and H_i with $\frac{w_i}{P_i}^{\frac{(1-\eta)\varepsilon}{(1+\varepsilon\eta)}}$

$$\widehat{W}_i = (1-\eta)^{\frac{1}{1-\eta}} (\frac{w_i H_i}{P_i})^{-1} \left[\frac{(\frac{w_i'}{P_i'})^{\frac{(1+\varepsilon)(1-\eta)}{(1+\eta\varepsilon)}}}{1-\eta} - \frac{(\frac{w_i'}{P_i'})^{\frac{(1+\varepsilon)(1-\eta)}{(1+\eta\varepsilon)}}}{\frac{1+\varepsilon}{\varepsilon}} + \frac{(\frac{w_i}{P_i})^{\frac{(1+\varepsilon)(1-\eta)}{(1+\eta\varepsilon)}}}{\frac{1+\varepsilon}{\varepsilon}}\right]^{\frac{1}{1-\eta}} - 1$$

$$\widehat{W}_i = (\frac{w_i}{P_i})^{-\frac{(1+\varepsilon)}{(1+\eta\varepsilon)}} \left[\left(1 - \frac{(1-\eta)\varepsilon}{1+\varepsilon}\right)(\frac{w_i'}{P_i'})^{\frac{(1+\varepsilon)(1-\eta)}{(1+\eta\varepsilon)}} + \frac{(1-\eta)\varepsilon}{1+\varepsilon}(\frac{w_i}{P_i})^{\frac{(1+\varepsilon)(1-\eta)}{(1+\eta\varepsilon)}}\right]^{\frac{1}{1-\eta}} - 1$$

Now replacing $\frac{w_i}{P_i} = \pi_{ii}^{-1/\theta} T_i^{1/\theta}$:

$$\widehat{W}_i = \pi_{ii}^{\frac{(1+\varepsilon)}{(1+\eta\varepsilon)\theta}} T_i^{-\frac{(1+\varepsilon)}{(1+\eta\varepsilon)\theta}} \left[\left(1 - \frac{(1-\eta)\varepsilon}{1+\varepsilon}\right) \pi_{ii}^{\prime -\frac{(1+\varepsilon)(1-\eta)}{(1+\eta\varepsilon)\theta}} T_i^{\prime \frac{(1+\varepsilon)(1-\eta)}{(1+\eta\varepsilon)\theta}} + \frac{(1-\eta)\varepsilon}{1+\varepsilon} \pi_{ii}^{-\frac{(1+\varepsilon)(1-\eta)}{(1+\eta\varepsilon)\theta}} T_i^{\frac{(1+\varepsilon)(1-\eta)}{(1+\eta\varepsilon)\theta}} \right]^{\frac{1}{1-\eta}} - 1$$

Under the assumption of $T_i' \equiv T_i$

$$\widehat{W}_i = \left[\widehat{\pi}_{ii}^{-\frac{(1+\varepsilon)(1-\eta)}{(1+\eta\varepsilon)\theta}} - \frac{(1-\eta)\varepsilon}{1+\varepsilon} \widehat{\pi}_{ii}^{-\frac{(1+\varepsilon)(1-\eta)}{(1+\eta\varepsilon)\theta}} + \frac{(1-\eta)\varepsilon}{1+\varepsilon} \right]^{\frac{1}{1-\eta}} - 1$$

re-arranging yields:

$$\widehat{W}_i = \widehat{\pi}_{ii}^{-\frac{(1+\varepsilon)}{(1+\eta\varepsilon)\theta}} \left[1 - \frac{(1-\eta)\varepsilon}{1+\varepsilon} \left(1 - \widehat{\pi}_{ii}^{\frac{(1+\varepsilon)(1-\eta)}{(1+\eta\varepsilon)\theta}} \right) \right]^{\frac{1}{1-\eta}} - 1$$

QED.

Following the same steps, it can be shown that the welfare gains from trade when $\eta \to 1$ are the same as in the standard Eaton and Kortum model $\hat{W}_i = \hat{\pi}_{ii}^{-\frac{1}{\theta}} - 1$.

Next I show that the welfare gains from trade are always larger when labor supply is elastic. For this to be the case I compare the absolute value of the equivalent variation between the two equilibria. The welfare gains from trade are larger only if the following condition holds

$$\hat{\pi}_{ii}^{-\frac{(1+\varepsilon)}{(1+\eta\varepsilon)\theta}} \left[1 - \frac{(1-\eta)\varepsilon}{1+\varepsilon} \left(1 - \hat{\pi}_{ii}^{\frac{(1+\varepsilon)(1-\eta)}{(1+\eta\varepsilon)\theta}} \right) \right]^{\frac{1}{1-\eta}} > \hat{\pi}_{ii}^{-\frac{1}{\theta}}$$

There are two relevant cases. The one with $\eta > 1$ and $\eta < 1$. I first show the case for $\eta > 1$. In addition, recall that the model assumes $\varepsilon > 0$ and $\theta > 1$.

$$\hat{\pi}_{ii}^{-\frac{(1+\varepsilon)}{(1+\eta\varepsilon)\theta}} \left[1 - \frac{(1-\eta)\varepsilon}{1+\varepsilon} \left(1 - \hat{\pi}_{ii}^{\frac{(1+\varepsilon)(1-\eta)}{(1+\eta\varepsilon)\theta}} \right) \right]^{\frac{1}{1-\eta}} > \hat{\pi}_{ii}^{-\frac{1}{\theta}}$$

$$\hat{\pi}_{ii}^{-\frac{(1+\varepsilon)(1-\eta)}{(1+\eta\varepsilon)\theta}} \left[1 - \frac{(1-\eta)\varepsilon}{1+\varepsilon} \left(1 - \hat{\pi}_{ii}^{\frac{(1+\varepsilon)(1-\eta)}{(1+\eta\varepsilon)\theta}} \right) \right] < \hat{\pi}_{ii}^{\frac{-(1-\eta)}{\theta}}$$

Note that the inequality changes because the exponent is negative

$$\hat{\pi}_{ii}^{-\frac{\varepsilon(1-\eta)^2}{(1+\eta\varepsilon)\theta}} - \frac{(1-\eta)\varepsilon}{1+\varepsilon} \hat{\pi}_{ii}^{-\frac{\varepsilon(1-\eta)^2}{(1+\eta\varepsilon)\theta}} + \frac{(1-\eta)\varepsilon}{1+\varepsilon} \hat{\pi}_{ii}^{\frac{(1+\varepsilon)(1-\eta)-\varepsilon(1-\eta)^2}{(1+\eta\varepsilon)\theta}} < 1$$

Define $\alpha = -\frac{\varepsilon(1-\eta)^2}{(1+\eta\varepsilon)\theta} < 0$

$$\hat{\pi}_{ii}^{\alpha} - \frac{(1-\eta)\varepsilon}{1+\varepsilon} \hat{\pi}_{ii}^{\alpha} + \frac{(1-\eta)\varepsilon}{1+\varepsilon} \hat{\pi}_{ii}^{\alpha + \frac{(1+\varepsilon)(1-\eta)}{(1+\eta\varepsilon)\theta}} < 1$$

re-arranging

$$\hat{\pi}_{ii}^{\alpha} + \frac{(1-\eta)\varepsilon}{1+\varepsilon} \hat{\pi}_{ii}^{\alpha + \frac{(1+\varepsilon)(1-\eta)}{(1+\eta\varepsilon)\theta}} < 1 + \frac{(1-\eta)\varepsilon}{1+\varepsilon} \hat{\pi}_{ii}^{\alpha}$$

Which always holds because when trade costs increase $\hat{\pi}_{ii} > 1$, this leads to

$$\hat{\pi}_{ii}^{\alpha} < 1$$

and

$$\hat{\pi}_{ii}^{\alpha+\frac{(1+\varepsilon)(1-\eta)}{(1+\eta\varepsilon)\theta}} < \hat{\pi}_{ii}^{\alpha}$$

making the left-had side strictly smaller than the right-hand side.

Now I show that this condition also holds for $\eta < 1$

$$\hat{\pi}_{ii}^{-\frac{(1+\varepsilon)}{(1+\eta\varepsilon)\theta}}\left[1-\frac{(1-\eta)\varepsilon}{1+\varepsilon}\left(1-\hat{\pi}_{ii}^{\frac{(1+\varepsilon)(1-\eta)}{(1+\eta\varepsilon)\theta}}\right)\right]^{\frac{1}{1-\eta}} > \hat{\pi}_{ii}^{-\frac{1}{\theta}}$$

$$\hat{\pi}_{ii}^{-\frac{(1+\varepsilon)(1-\eta)}{(1+\eta\varepsilon)\theta}}\left[1-\frac{(1-\eta)\varepsilon}{1+\varepsilon}\left(1-\hat{\pi}_{ii}^{\frac{(1+\varepsilon)(1-\eta)}{(1+\eta\varepsilon)\theta}}\right)\right] > \hat{\pi}_{ii}^{-\frac{(1-\eta)}{\theta}}$$

$$\hat{\pi}_{ii}^{\alpha}\left[1-\frac{(1-\eta)\varepsilon}{1+\varepsilon}\left(1-\hat{\pi}_{ii}^{\frac{(1+\varepsilon)(1-\eta)}{(1+\eta\varepsilon)\theta}}\right)\right] > 1$$

$$\hat{\pi}_{ii}^{\alpha}-\frac{(1-\eta)\varepsilon}{1+\varepsilon}\hat{\pi}_{ii}^{\alpha}+\frac{(1-\eta)\varepsilon}{1+\varepsilon}\hat{\pi}_{ii}^{\alpha+\frac{(1+\varepsilon)(1-\eta)}{(1+\eta\varepsilon)\theta}} > 1$$

$$\frac{1+\eta\varepsilon}{1+\varepsilon}\hat{\pi}_{ii}^{\alpha}+\frac{(1-\eta)\varepsilon}{1+\varepsilon}\hat{\pi}_{ii}^{\alpha+\frac{(1+\varepsilon)(1-\eta)}{(1+\eta\varepsilon)\theta}} > 1$$

If $\varepsilon = 0$ then the left-hand side would be equal to one. But, the inequality holds with the assumed $\varepsilon > 0$ and increases in ε.

Derivation of the alternative expression of the welfare gains from trade as a function of trade and labor changes:

$$\hat{W}_i = (\frac{w_i H_i}{P_i})^{-1}\left[(\frac{w_i'}{P_i'})^{\frac{(1+\varepsilon)(1-\eta)}{(1+\eta\varepsilon)}}-\frac{(1-\eta)\varepsilon}{1+\varepsilon}(\frac{w_i'}{P_i'})^{\frac{(1+\varepsilon)(1-\eta)}{(1+\eta\varepsilon)}}+\frac{(1-\eta)\varepsilon}{1+\varepsilon}(\frac{w_i}{P_i})^{\frac{(1+\varepsilon)(1-\eta)}{(1+\eta\varepsilon)}}\right]^{\frac{1}{1-\eta}}-1$$

$$\hat{W}_i = \pi_{ii}^{\frac{1}{\theta}} H_i^{-1}\left[C_i'^{1-\eta}-\frac{(1-\eta)\varepsilon}{(1+\varepsilon)}H_i'^{1+\frac{1}{\varepsilon}}+\frac{(1-\eta)\varepsilon}{(1+\varepsilon)}H_i^{1+\frac{1}{\varepsilon}}\right]^{\frac{1}{1-\eta}}-1$$

$$\hat{W}_i = \pi_{ii}^{\frac{1}{\theta}}\left[(\frac{C_i'}{H_i})^{1-\eta}+\frac{(1-\eta)\varepsilon}{(1+\varepsilon)}H_i^{-(1-\eta)}\left(H_i^{1+\frac{1}{\varepsilon}}-H_i'^{1+\frac{1}{\varepsilon}}\right)\right]^{\frac{1}{1-\eta}}-1$$

$$\hat{W}_i = \hat{\pi}_{ii}^{-\frac{1}{\theta}}\left[\hat{H}_i^{1-\eta}+\frac{(1-\eta)\varepsilon}{(1+\varepsilon)}\pi_{ii}'^{\frac{(1-\eta)}{\theta}}H_i^{-(1-\eta)}H_i^{1+\frac{1}{\varepsilon}}\left(1-\hat{H}_i^{1+\frac{1}{\varepsilon}}\right)\right]^{\frac{1}{1-\eta}}-1$$

$$\hat{W}_i = \hat{\pi}_{ii}^{-\frac{1}{\theta}}\left[\hat{H}_i^{1-\eta}+\frac{(1-\eta)\varepsilon}{(1+\varepsilon)}\hat{\pi}_{ii}^{\frac{(1-\eta)}{\theta}}\left(1-\hat{H}_i^{1+\frac{1}{\varepsilon}}\right)\right]^{\frac{1}{1-\eta}}-1$$

E Additional robustness checks

In this appendix I provide some additional robustness checks. First, I estimate the equilibrium of hours worked including a measure of TFP and capital per worker. Then, I show that my empirical results are not driven by exclusively by low- and middle-income countries.

My model extended with capital predicts that the equilibrium of hours worked (32) depends on the domestic trade share, the average efficiency level (or TFP), and the stock of capital. I my main empirical analysis I omitted TFP and the stock of physical capital, which are part of the error term. One 'upward' bias concern arises if higher trade correlates with TFP or investment. Here I show that my instrument exploits variations that correlate with trade but are orthogonal to changes in measured TFP and investment. In other words, this is another test on the strength of the exclusion restriction.

I include a measure of TFP and capital stock from PWT in my baseline specification (17). Table A1 presents the results. The coefficient of the domestic trade share has roughly the same magnitude as in my main results and is statistically significant. It slightly changes from 0.51 to 0.58. This shows that there is no significant 'upward' bias in my baseline specification, and that the effect of the domestic trade share on trade is not confounded by TFP changes. As predicted by the theory, TFP has a negative coefficient, but is not statistically significant at the 10 percent level. Capital per worker is also not statistically significant.

The income effects of trade on hours worked could be potentially driven by low- and middle-income countries where households work the most. It can be thought that beyond some income threshold, the income effects fade away. This is the logic behind employing Stone-Geary type preferences in some studies (Ohanian et al., 2008). To provide evidence that my results are not driven exclusively by low- and middle-income countries, I restrict the sample to OECD countries. I estimate the main three specification described in Section 4.1 on a sample of 17 OECD countries. These countries comprise almost 50 percent of the total observations in my original sample.

Table A2 shows the estimates of the two specifications. Column 1 presents the impact of the domestic trade share on hours per worker and column 2 on income per worker. The two estimated coefficients have the expected sign and their magnitudes do not vary significantly with respect to my baseline results (Tables 2 and 4). However, the do present slightly smaller coefficients (in absolute terms).

Next, I show that my baseline results are robust to using alternative weights in the construction of the instrument for trade. As discussed in 4.2, my instrument for trade can be built using any weights to aggregate across importing partners. Here I present the the results of using initial population (population in 1950) in trading partner, and total initial trade (trade amount in 1950) as alternative weighing measures. Columns 1-3 in Table A3 show the second stage estimates of regressing hours per worker on the domestic trade share. Column 1 replicates the baseline results of Table 2, column 2 displays the use of initial population as weights, and column 3 initial trade. Employing the two alternative instruments continues to display a positive and significant impact of trade closeness and hours per worker. The F-stat is larger than 10 for initial population but slightly below for initial trade (which could explain its large estimated coefficient). Columns 4-6 show the reduced-form regressions. As in the results presented in column 4, an increase in predicted trade causes a decline in hours per worker. All coefficients are significant at the 5 percent level.

Table A1: Robustness: controlling for TFP and capital

	(1)	(2)
	Dependent variable: log hours per worker	
log domestic trade share	0.506**	0.575**
	(0.217)	(0.261)
log TFP		-0.078
		(0.0546)
log capital per worker		0.0357
		(0.0283)
Country and year FE	yes	yes
Observations	303	303
F-stat in first stage	15.42	8.757
Countries	42	42

Note: This table reports the IV estimates of regressing hours worked per worker on the domestic trade share, TFP and capital stock per worker. TFP and stock of physical capital are from PWT 9.0. The panel comprises 5-years intervals of data between 1950 and 1995 for 42 countries. All specifications include country and year fixed effects. The instrument log predicted trade is constructed based on equation (20). The F-stat is the Kleiberg-Paap Wald F-statistics for weak identification. Standard errors (reported in parentheses) are clustered at the country level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table A2: Robustness: only OECD countries

	(1)	(2)
	Dependent variable:	
	log hours per worker	log GDP per worker
log domestic trade share	0.355*	-4.230***
	(0.194)	(1.276)
Country and year FE	yes	yes
Observations	158	158
F-stat in first stage	22.8	22.8
Countries	17	17

Note: This table replicates the IV estimates of hours per worker on the domestic trade share, and GDP per worker on domestic trade share for a sample of only high income OECD countries. The panel comprises 5-years intervals of data between 1950 and 1995 for 17 countries, detailed in Table A4. All specifications include country and year fixed effects. The instrument log predicted trade is constructed based on equation (20). The F-stat is the Kleiberg-Paap Wald F-statistics for weak identification. Huber-White Standard errors are reported in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table A3: Robustness: alternative weights in the construction of the instrument

	(1)	(2)	(3)	(4)	(5)	(6)
			Dependent variable: log hours per worker			
	IV	IV	IV	OLS	OLS	OLS
log domestic trade share	0.507**	0.802***	1.031***			
	(0.217)	(0.203)	(0.258)			
log predicted trade (initial bilateral trade)				-0.081**		
				(0.039)		
log predicted trade (initial population)					-0.129***	
					(0.035)	
log predicted trade (initial trade volume)						-0.139***
						(0.040)
Observations	321	321	321	321	321	321
Country and year FE	yes	yes	yes	yes	yes	yes
F-stat	15.45	17.07	9.16			
R^2				0.061	0.173	0.188
Countries	45	45	45	45	45	45

Note: This table reports IV estimates of regressing hours per worker on the domestic trade share using different instruments for trade. Columns 1, 2 and 3 show the second stage when the weights in predicted trade are initial bilateral trade, initial population size and initial total trade, respectively. Columns 4-6 display the reduced form of these instruments. All specifications include country and year fixed effects. The F-stat is the Kleiberg-Paap Wald F-statistics for weak identification. Standard errors (reported in parentheses) are clustered at the country level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

F Other tables and figures

Table A4: 45 countries included in the dataset

Argentina, *Australia**, Bangladesh, Brazil*, Bulgaria, *Canada**, Chile, Colombia, Costa Rica, *Denmark**, Estonia, *Finland**, *France**, *Germany**, *Greece**, India*, Indonesia, *Ireland**, Israel, *Italy**, Jamaica, *Japan**, Latvia, Lithuania, Malaysia, Mexico*, *Netherlands**, *New Zealand*, *Norway*, Pakistan, Peru, Philippines, Poland, *Portugal**, Republic of Korea*, Russia, *Spain**, Sri Lanka, *Sweden**, Thailand, Turkey, *United Kingdom**, *United States**, Uruguay, Viet Nam.

Note: Countries in italics are the OECD countries used in the robustness exercise. Countries with * are part of the long-run WIOD database.

Table A5: Main descriptive statistics

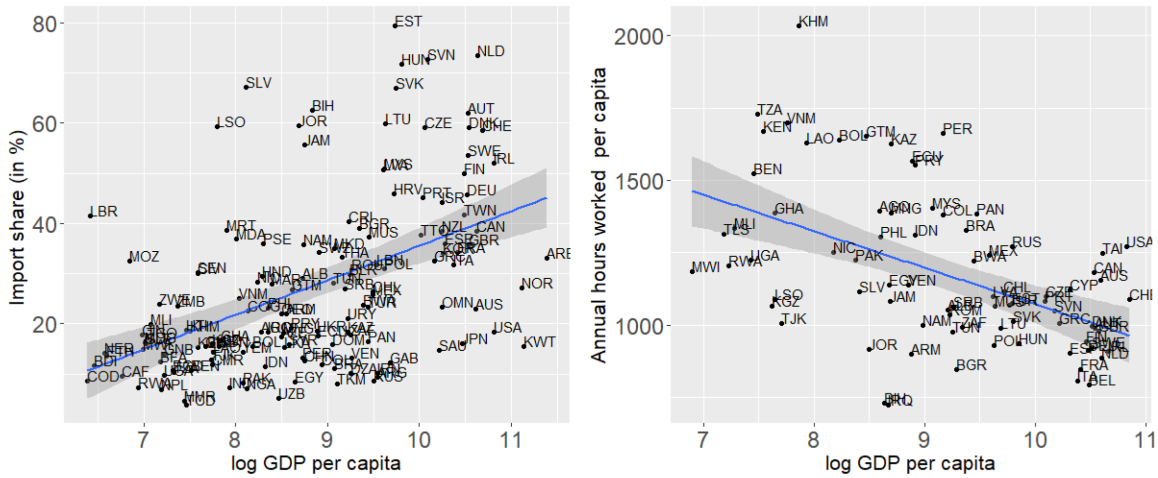
	obs	mean	s.d.	min	max
Hours per worker	324	2042.3	251.27	1439.92	2921.48
Employment rate	633	0.37	0.08	0.18	0.56
Domestic trade share	673	0.83	0.11	0.50	0.99
log predicted trade	673	4.02	3.15	-1.58	12.10
log GDP per worker	633	9.44	0.99	6.18	13.06

Note: Sample 1950-1995. Countries with population larger than a million inhabitants and domestic share between 0.5 and 1.

Figure 3: Trade and hours: the income channel

(a) Trade and income

(b) Hours per capita and income

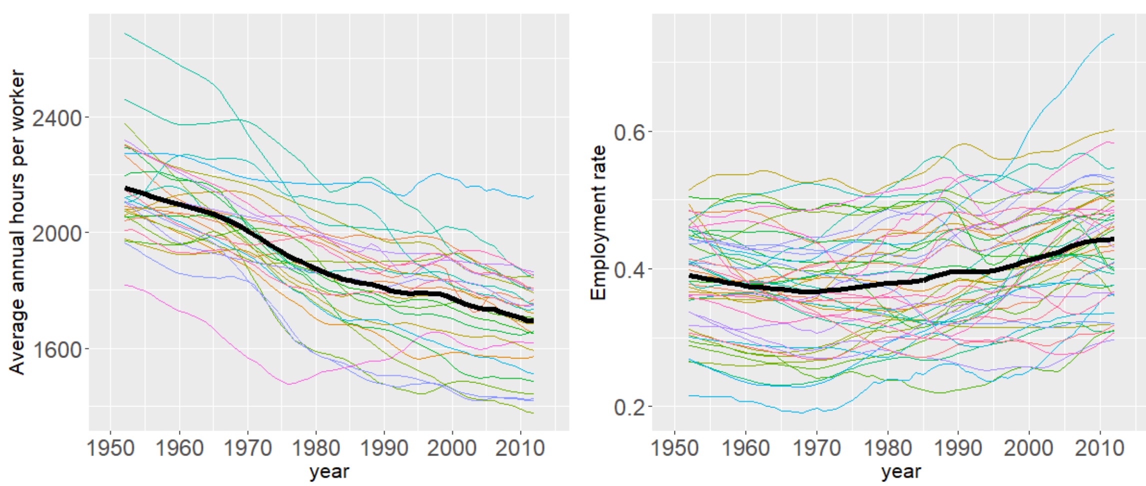


Source: Bick et al. (2018) and PWT.

Figure 4: Hours worked along the intensive and extensive margin

(a) Hours per worker

(b) Employment rate



Note: 5-year moving average was applied to all series.
Black solid line represents simple mean across countries. Source: PWT

PUBLICATIONS

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