Capital goods, measured TFP and growth: The case of Spain

by

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October 2014

Center for Fiscal Policy Working Paper Series

Working Paper 01-2014

Capital goods, measured TFP and growth: The case of Spain*

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November 5, 2014

Abstract

This paper reconciles two, apparently, contradictory facts about the Spanish economy: real GDP per working age person has grown at 2.4 percent during the period 1996-2007, on average, whereas Total Factor Productivity has been stagnant during that period. Here we argue that the Spanish economy has grown, in spite of stagnant TFP, because investment in structures has been heavily subsidized. This inefficiently high rate of investment in structures is the main reason for the increase in hours worked observed during that period. We use a three sector model economy where we distinguish between equipment and structures to quantify the sources of changes in measured TFP in Spain. We find that measured TFP is low because Investment-Specific Technical Change in Spain is very low. A calibrated version of this model is able to reproduce very well the growth experience of Spain for the period 1970-2007. We use the model economy to quantify the cost of direct and indirect subsidies to structures and the gains of eliminating them in terms of TFP and income growth. Our three sector model economy also allows us to quantify the cost in measured TFP of the housing price boom experienced during the 2000s.

Keywords: Spain, TFP, growth accounting, ISTC, applied general equilibrium.
JEL Classification: E01, E13, E32.

*We thank Ángel Estrada and Elena Márquez for sharing with us their series of aggregate expenditures in consumer durable goods. Antonia Díaz thanks the Bank of Spain for financial support. We thank Andrés Erosa and Luis A. Puch for helpful comments and suggestions.

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1 Introduction

One of the most striking facts about the Spanish economy is its ability to grow in spite of very low Total Factor Productivity. In particular, real GDP per working age person has grown at 2.4 percent during the period 1996-2007, on average, whereas Total Factor Productivity has been stagnant during that period. Here we argue that TFP is low because Investment Specific Technical Change is very low. In spite of it, the Spanish economy has grown because investment in structures has been heavily subsidized. In other words, investment in structures in Spain is inefficiently high. This huge investment is the main reason for the increase in hours worked observed during the period 1996-2007.

To quantify the importance of this mechanism we build on Greenwood et al. (1997) and construct a three sector growth model economy where we distinguish between equipment and structures. Differently from those authors, we assume that the relative price of structures is not constant. We use the methodology developed by Kehoe and Prescott (2002) to study great recessions and apply it to Spain. We assume that the return to structures is subsidized. To isolate the effect of such a subsidy we assume that it is financed, along with the rest of government expenditures, with lump-sum taxes. We calibrate our model economy to match selected statistics of the Spanish economy during the period 1970-2007. When organizing the evidence, we find some facts about Spain are very striking. One first fact that we find is that Spain uses very intensively structures. The ratio of structures to output is 2.2, whereas it is 1.6 for the US for the period 1970-2007. This difference is in real units. We compare our relative price of residential structures with its counterpart for the US, calculated by Davis and Heathcote (2007), and we find essentially the same number for the period 1975-2007. Next, the equipment to output ratio is similar in Spain and the US, 0.71 versus 0.7 respectively. This similarity, however, is mostly nominal, as the relative price of business equipment falls more rapidly in the US than in Spain. Since the relative price of equipment reflects Investment Specific Technical Change, we can conclude that in Spain there is less equipment—and its quality is lower—than in the US in the aggregate. We also find that the Spanish economy is standard in terms of the factorial distribution of income when compared with similar calibrations for the US economy (Cooley and Prescott (1995), Greenwood et al. (1997)) and in line with other calibrations for the Spanish economy. See for example Puch and Licandro (1997). The most particular feature of our calibration, however, is the labor supply elasticity. As it is well know, hours worked in

Spain fluctuate a lot, structural unemployment is high and it is very persistent over time. Thus, we calibrate the utility function of the representative dynasty so that the variance of hours worked in the model match that observed in the data and that average hours worked per worker are as low as in the data. Finally, we estimate a series for the subsidy on structures as a "wedge", so that investment in structures matches that observed in the data for the entire period 1970-2007.

Our growth accounting exercise based on the methodology of Hayashi and Prescott (2002) allows us to measure the contribution of neutral technical progress, ISTC (proxied by the relative price of equipment), changes in the relative price of structures, and changes in the capital mix to the observed growth rate of TFP. We find that the average growth rate of TFP during the period 1970-2007 was 0.94. The contribution of neutral technical progress is higher, though, 1 percent. ISTC in equipment contributes 0.4 percent to that meager growth rate. Fluctuations in the relative price of structures and changes in the mix of capital used in production are responsible for the low observed TFP.

Our benchmark model economy matches very well the growth patterns of Spain for the period 1970-2007. In particular, it is able to pick the upsurge of hours worked observed during the period 1996-2007. We find that the subsidy needed for investment in structures to be as high as in the data is, on average, 80 percent. That is, the after tax return on structures is almost doubled by the subsidy. To quantify the importance of such subsidy and the low growth in ISTC we conduct a series of counterfactual experiments incrementally. We find that eliminating those subsidies reduces income growth up to two thirds the observed growth rate. TFP is not affected in the long run, since subsidies affect capital accumulation. Eliminating the observed upsurge of structures prices would have added 0.52 percent points to observed growth rate and 0.33 percentage points to TFP. The key factor to rise the long run growth rate of output and TFP is higher ISTC growth rate. If the relative price of equipment in Spain fell at the same rate that the relative price of business equipment in the U.S. the average growth rate of output per worker during the period 1970-2007 would have been 1.43 percentage points higher. Finally, we assess the effect of a labor market reform on output and TFP growth and argue that a labor marker reform would have a level effect on output, but it would not affect the growth rate of TFP.

Our paper belongs to that branch of the literature that studies great recessions, such as Kehoe and Prescott (2002), Conesa et al. (2007), and others. We also contribute to the literature on growth accounting and Investment Specific Technical Change (see, for instance, Greenwood et al.,

1997; Oulton, 2007) and illustrate the connection between ISTC and the standard measure of TFP. We show that a one sector growth model, properly calibrated, delivers the same patterns that our benchmark economy with three sectors. The advantage of our three sector economy is that allows us to isolate the sources of low TFP. Moreover, it allows us to quantify the cost in terms of measured TFP of a rise in the relative price of structures. We find that this cost is significant. Chen et al. (2006) use a similar approach to understand the differences in the saving rate in Japan versus the US economy in a one sector growth model environment. In our model we differentiate between equipment and structures to account for the forces behind the evolution of the TFP.

Other papers has quantified the impact of ISTC on output growth in Spain. Martínez et al. (2008) use a dynamic general equilibrium model with six different capital inputs into the production function to quantify the impact of the information and communication technology (ICT) on growth of market output in Spain between 1995 and 2002 (they exclude housing from their analysis). However, their analysis assumes that the Spanish economy is in a Balanced Growth Path during this period. Our paper shows that it is important departing from this assumption. The reason is that in a balanced growth path there are no changes in the mix of capital, as opposed to a transition. This compositional effect is important to understand the behavior of measured TFP in Spain.

The rest of the paper is organized as follows: Section 2 presents our benchmark model economy and our growth accounting methodology. In Section 3 we discuss the data used and some particular features of the growth patterns in Spain as well as our calibration strategy. Section 4 presents our main results. Section 5 discusses some features of the Spanish economy that may be important to understand the sources of low TFP. Finally, Section 6 concludes.

2 The benchmark model economy

Our model economy is an infinite horizon economy. Time is discrete.

2.1 Preferences and endowments

There is a representative dynasty that seeks to maximize expected discounted lifetime utility,

$$\sum_{t=0}^{\infty} \beta^t N_t \left[\ln\left(c_t + \eta\, g_t\right) + \phi\, \frac{\ell_t^{1-\sigma}}{1-\sigma} \right],\ \phi > 0,\ \sigma > 0, \tag{2.1}$$

where N_t is the size of the dynasty at time t, c_t is private consumption, g_t denotes services provided by the government, in per capita terms, and ℓ_t is leisure at time t per dynasty member. Each member of the dynasty is endowed with $\hbar$ units of time and, therefore, works $h_t = \hbar - \ell_t$ hours every period. The size of the dynasty, N_t, evolves exogenously.

2.2 Technology

The production of final output Y requires of labor services, H, and two types of capital, equipment and structures. Production takes place in accordance to the aggregate production function

$$Y_t = Z_t \left(K_t^e\right)^{\alpha_e} \left(K_t^s\right)^{\alpha_s} H_t^{1-\alpha_e-\alpha_s}, \quad 0 < \alpha_e,\, \alpha_s,\; \alpha_e + \alpha_s < 1. \tag{2.2}$$

The variable Z_t is a measure of neutral technical progress. There is a technology that allows agents to transform final good of period t into Θ_t^i units of new capital of type i,

$$X_t^i = \Theta_t^i \, I_t^i. \tag{2.3}$$

Capital accumulates according to the law,

$$K_{t+1}^i = X_t^i + \left(1 - \delta^i\right) K_t^i. \tag{2.4}$$

The depreciation rate is denoted as δ^i. Changes in Θ_t^j, $j = e,\, s$ formalize the notion of investment specific technical change (ISTC hereafter). As in Greenwood et al. (1997), technical change makes new capital either less expensive or better than old capital, allowing to increase consumption.

2.3 Market arrangements and government policy

The dynasty is the owner of all technologies and production factors. Additionally, the dynasty can use a bond to save or borrow. Its real return, in units of consumption good, is r_t^b. This is a closed economy. In Section 4.7 we will study its open counterpart.

We assume that there is government that subsidizes the gross return to structures at the rate ξ_t. This subsidy is meant to capture all market frictions whose final effect is to distort the market return to structures. Additionally, the government finances the public consumption good, g_t, which

affects marginal utility of private consumption, and public investment, I_t^g, which does not affect marginal utility. To focus our attention on the effects of the distortion implied by the structures subsidy, we assume that the subsidy and government expenditures are all financed with lump-sum taxes. The government's budget is balanced every period.

2.4 Competitive equilibrium

The problem solved by the firm that produces the final good is static:

$$\max_{K_t^e, K_t^s, H_t} Z_t \left(K_t^e\right)^{\alpha_e} \left(K_t^s\right)^{\alpha_s} H_t^{1-\alpha_e-\alpha_s} - r_t^e\, K_t^e - r_t^s\, K_t^s - w_t\, H_t. \tag{2.5}$$

Likewise, we assume that the firms producing equipment and structures are perfectly competitive and solve the problem:

$$\begin{aligned} \max_{X_t^j, I_t^j} \quad & q_t^j\, X_t^j - I_t^j \\ \text{s. t.} \quad & 0 \leq X_t^j \leq \Theta_t^j\, I_t^j. \end{aligned} \tag{2.6}$$

The representative dynasty's problem is

$$\begin{aligned} \max_{\substack{c_t, h_t, x_t^e, x_t^s \\ k_{t+1}^e, k_{t+1}^s, \\ b_{t+1}}} \quad & \sum_{t=0}^{\infty} \beta^t\, N_t \left[\ln\left(c_t + \eta\, g_t\right) + \phi\, \tfrac{(\hbar - h_t)^{1-\sigma}}{1-\sigma}\right] \\ \text{s. t.} \quad & c_t + q_t^e\, x_t^e + q_t^s\, x_t^s + \tfrac{N_{t+1}}{N_t}\, b_{t+1} - b_t \leq w_t\, h_t + r_t^e\, k_t^e + (1+\xi_t)\, r_t^s\, k_t^s + r_t^b\, b_t - \tau_t \\ & x_t^e \geq 0,\ x_t^s \geq 0, \\ & 0 \leq \tfrac{N_{t+1}}{N_t}\, k_{t+1}^e \leq x_t^e + (1-\delta^e)\, k_t^e, \\ & 0 \leq \tfrac{N_{t+1}}{N_t}\, k_{t+1}^s \leq x_t^s + (1-\delta^s)\, k_t^s, \\ & b_{t+1} \geq -\underline{b}, \\ & k_0^e,\ k_0^s,\ b_0 \ \text{ given.} \end{aligned} \tag{2.7}$$

Definition 1. *A competitive equilibrium for this economy, given the government policy* $\left\{\xi_t, \tau_t, g_t, I_t^g\right\}_{t=0}^{\infty}$, *is a sequence of prices,* $\left\{w_t, r_t^e, r_t^s, q_t^e, q_t^s\, r_t^b\right\}_{t=0}^{\infty}$, *an allocation for the firm producing the final good,* $\left\{Y_t, K_t^e, K_t^s, L_t\right\}_{t=0}^{\infty}$, *an allocation for the firms producing equipment and structures, respectively,* $\left\{X_t^e, I_t^e\right\}_{t=0}^{\infty}$, *and* $\left\{X_t^s, I_t^s\right\}_{t=0}^{\infty}$, *and an allocation for the representative dynasty,* $\left\{c_t, h_t, x_t^e, x_t^s, k_{t+1}^e, k_{t+1}^s, b_{t+1}\right\}_{t=0}^{\infty}$ *such that:*

1. *Rental prices of factors are equal to their marginal productivities.*

2. *The price of investment in capital goods are, respectively,* $q_t^e = 1/\Theta_t^e$, *and* $q_t^s = 1/\Theta_t^s$.

3. $\left\{c_t, h_t, x_t^e, x_t^s, k_{t+1}^e, k_{t+1}^s, b_{t+1}\right\}_{t=0}^{\infty}$ *solves the consumer's problem given the government policy and the sequence of prices.*

4. *Government budget is balanced,* $N_t\,\tau_t = \xi_t\, r_t^s\, K_t^s + N_t\, g_t + I_t^g$.

5. *Markets clear:*

   (a) $K_t^i = N_t\, k_t^i$, $i = e,\, s$,

   (b) $H_t = N_t\, h_t$,

   (c) $X_t^i = N_t\, x_t^i$,

   (d) $Y_t = N_t\, c_t + I_t^e + I_t^s + N_t\, g_t + I_t^g$.

2.5 The balanced growth path

This economy has a balanced growth path where the growth rate of output is a weighted geometrical average of the growth rate of neutral technical progress and ISTC.

Proposition 1. *Assume that population grows at the constant rate* $n > 0$, *and that the government policy is invariant over time,* $\xi_t = \xi$, $g_t = g$, *and* $I_t^g = I^g$, *for all* t. *Assume further that neutral progress as well as investment specific technical change all grow at a constant rate,* $Z_{t+1}/Z_t = 1+\zeta$, $\Theta_t^j/\Theta_{t+1}^j = 1+\theta^j$, $j = e,\, s$. *Then, this economy has a balanced growth path along which all variables grow at a constant rate:*

1. *Output and consumption per capita grow at the rate*

$$\frac{y_{t+1}}{y_t} = 1 + g_y = (1+\zeta)^{\frac{1}{1-\alpha_e-\alpha_s}}\,(1+\theta^e)^{\frac{\alpha_e}{1-\alpha_e-\alpha_s}}\,(1+\theta^s)^{\frac{\alpha_s}{1-\alpha_e-\alpha_s}}\,, \tag{2.8}$$

2. *equipment and structures grow, respectively, at the rate*

$$1 + g_j = \left(1+\theta^j\right)\,(1+g_y)\,, \tag{2.9}$$

3. the return to different assets satisfy

$$1+g_y=\beta\left(1+r^b\right)=\frac{\beta\left[q^e_{t+1}(1-\delta^e)+r^e_{t+1}\right]}{q^e_t}=\frac{\beta\left[q^s_{t+1}(1-\delta^e)+(1+\xi)\,r^s_{t+1}\right]}{q^s_t}, \quad (2.10)$$

4. and per capita hours worked are constant.

Proof see Appendix A.

It is clear from expression (2.8) that the lower the level of technical change specific to either type of capital, the lower is the growth of output. In our theory, the evolution of the relative price of capital is governed by the evolution of ISTC. Thus, the lower the fall in the relative price of capital, the lower is ISTC and the growth rate of output. We will measure this effect in Section 2.6 when we assess quantitatively the effect of rising relative prices of structures on measured TFP. It is also clear from expression (2.10) that, along the balanced growth path, the subsidy on the gross return to structures is equivalent to subsidizing the fraction $\xi/(1+\xi)$ of the price of investing in structures, q_s.

2.6 Growth accounting and the measurement of TFP

Let us write our production function (2.2) in per capita terms:

$$y_t=Z_t\,(k^e_t)^{\alpha_e}\,(k^s_t)^{\alpha_s}\,h_t^{1-\alpha_e-\alpha_s}. \quad (2.11)$$

Following Hayashi and Prescott (2002), it is possible to rewrite the production function as:

$$y_t=(Z_t)^{\frac{1}{1-\alpha_e-\alpha_s}}\left(\frac{1}{q^e_t}\right)^{\frac{\alpha_e}{1-\alpha_e-\alpha_s}}\left(\frac{1}{q^s_t}\right)^{\frac{\alpha_s}{1-\alpha_e-\alpha_s}}\left(\frac{q^e_t k^e_t}{y_t}\right)^{\frac{\alpha_e}{1-\alpha_e-\alpha_s}}\left(\frac{q^s_t k^s_t}{y_t}\right)^{\frac{\alpha_s}{1-\alpha_e-\alpha_s}}h_t. \quad (2.12)$$

We will use this expression to obtain the series of neutral technological progress in the data. Notice that in a balanced-growth path, the last three terms are constant and growth in y_t is driven by growth in $(Z_t)^{\frac{1}{1-\alpha_e-\alpha_s}}\left(\frac{1}{q^e_t}\right)^{\frac{\alpha_e}{1-\alpha_e-\alpha_s}}\left(\frac{1}{q^s_t}\right)^{\frac{\alpha_s}{1-\alpha_e-\alpha_s}}$.

In order to measure TFP we need to look at the data through the lenses of a one sector growth

model, instead of our three sector growth model. Comparing both technologies:

$$Y_t = Z_t \, (K_t^e)^{\alpha_e} \, (K_t^s)^{\alpha_s} \, H_t^{1-\alpha_e-\alpha_s}, \tag{2.13}$$

$$Y_t = A_t \, \mathcal{K}_t^{\alpha} H_t^{1-\alpha}, \tag{2.14}$$

where $\mathcal{K}_t$ is aggregate capital measured in units of final output, it is easy to see that Total Factor Productivity, A_t, satisfies:

$$A_t = Z_t \, (q_t^e)^{-\alpha_e} \, (q_t^s)^{-\alpha_s} \left(\frac{q_t^e \, K_t^e}{\mathcal{K}_t} \right)^{\alpha_e} \left(\frac{q_t^s \, K_t^s}{\mathcal{K}_t} \right)^{\alpha_s}. \tag{2.15}$$

This expression shows that changes in measured TFP arise from changes in neutral technical change, Z_t, changes in ISTC, $(q_t^e)^{-\alpha_e}$ and $(q_t^s)^{-\alpha_s}$, and changes in the composition of capital, $(q_t^e \, K_t^e/\mathcal{K}_t)^{\alpha_e}$ and $(q_t^s \, K_t^s/\mathcal{K}_t)^{\alpha_s}$. In a balanced growth path the composition of capital does not change and measured TFP is given by the combination of neutral progress and ISTC. Out of the balanced growth path, changes in the mix of capital will show up as changes in TFP. In particular, any policy that rises the weight of structures in aggregate capital above the optimal weight, $\alpha^s / (\alpha^e + \alpha^s)$, will imply a fall in TFP.

3 Taking the model to the data

In this section we describe the data used and the procedure to calibrate our benchmark model economy.

3.1 Data sources

We use data collected by the Ministry of Public Finance and Administration, the *Macroeconomic Data Base of Spain* (BDMACRO hereafter), which comprises the main macro aggregates of the Spanish economy starting form 1954 at the annual frequency. This database, though, does not disaggregate investment by type, although it decomposes public expenditures in consumption and investment. It does not contain information about expenditures in durable consumption goods, since it only provides the private consumption aggregate. The advantage of this database, though, is that it links all the historical macroeconomic data collected by the *Instituto Nacional de Es-*

tadística, (INE hereafter), the institution that constructs the Spanish National Accounts. The *Instituto Valenciano de Investigaciones Económicas* (IVIE hereafter) collects detailed information about investment disaggregated by type and ownership since 1954. It also calculates capital stocks by type and ownership using the perpetual inventory method. The main investment aggregates are consistent with those reported by BDMACRO and, therefore, the INE. The IVIE, though, does neither use investment prices adjusted by quality nor it uses a geometric depreciation rate when it calculates the capital stocks for the period 1954-1969. It does so for the data constructed for the EU KLEMS project.[1] The price of investment structures does not include the value of land. This is the common practice in National Accounts since changes in the price of land produce transfers of resources across agents but do not affect productivity of factors. The disadvantage is that the data in EU KLEMS starts in 1970. The EU KLEMS project also provides information about the components of National Income.

Our theory does not distinguish between residential and non residential structures. The key difference between both is that services of owner occupied residential stock are not part of market output although most countries, including Spain, include an estimate of the market value of their services in measured GDP. We should view our economy as one in which residential assets are perfectly liquid and there are perfect credit markets. Under these assumptions, the market allocation is invariant to the existence (or not) of a rental market for residential assets: see, for instance, Davis and Heathcote (2005) or Díaz and Luengo-Prado (2010). In our theory market consumption is non durable. For this reason we include consumer durable goods as part of the stock of equipment. To be consistent, we augment measured GDP with the value of the services provided by the stock of consumer durable goods in a manner specified below. The original series of expenditures in durable consumption goods was constructed by Estrada and Sebastián (1993) and updated by Márquez (2004) to assess the intertemporal elasticity of aggregate consumption in Spain[2].

3.2 The relative price of investment goods and the stock of structures and equipment

Our measure of capital is composed by private capital and durable consumption goods. We have not included capital owned by the government but privately owned infrastructures, such as private

[1] in `http://www.euklems.net/index.html`

[2] See Márquez (2005).

highways, are included in our measure of structures. The EU KLEMS database divides investment in eight categories. Two of them are *Residential investment* and *Other constructions*. The other categories correspond to various form of equipment, including software. EU KLEMS also provides deflators for the eight categories and calculates the capital stock using a perpetual inventory method. We create two composite categories: *Structures* and *Equipment*. The category Structures corresponds to *Residential investment* and *Other constructions*, whereas Equipment comprises the other six categories plus durable consumption goods.

We take from EU KLEMS the implicit price deflator of each type of investment good, $D^j_{i\,t}$ and we construct the implicit price deflator of non durable goods and services, $D_{ndc\,t}$ using the data of Estrada and Sebastián (1993) and Márquez (2004). We define the relative price of the investment good i in category j as $q^j_{i\,t} = D^j_{i\,t}/D_{ndc\,t}$. We construct a constant-price measure of investment in category j as $X^j_t = \sum_i q^j_{i\,0} X^j_{i\,t}$. We take as base year 1996. Thus, the implicit price deflator of $j = e,\, s$, is

$$q^j_t = \frac{\sum_i q^j_{i\,t} X^j_{i\,t}}{X^j_t}. \tag{3.1}$$

Next, we calculate the real stock of each category j so that

$$K^j_t = \frac{\sum_i q^j_{i\,t} K^j_{i\,t}}{q^j_t}, \tag{3.2}$$

where $K^j_{i\,t}$ is the real capital stock calculated by EU KLEMS for each type of investment good but consumer durable goods, type for which we calculate the real stock. Using a perpetual inventory method backwards we compute the average depreciation rate for the period 1970-2008, which are $\delta^s = 0.013$, and $\delta^e = 0.1645$.

To construct aggregates for the composite *Equipment* we need to compute the stock of durable consumption goods. Prior to 1995, the Spanish National Accounts do not report disaggregated information on consumption expenditures. For the period 1964-1995, we use the data collected by Estrada and Sebastián (1993) and Márquez (2004), who also report the implicit price deflator for the disaggregated consumption expenditure components. Our definition of consumer durable goods is slightly different from that used by the aforementioned authors since we do not include private expenditures in schooling. We calculate the stock of consumer durable goods by applying

a perpetual inventory method for the period 1964-2008, last year for which we have disaggregated consumption data. Let I_t^d be the expenditure in durable goods in current euros at time t. We obtain its relative price, q_t^d, by dividing its deflator by the implicit price deflator of non durable goods and services. We follow Puch and Licandro (1997) and assume that consumption durable goods have a depreciation rate of $\delta^d = 0.21$. Thus,

$$K_{t+1}^d = X_t^d + \left(1 - \delta^d\right) K_t^d. \tag{3.3}$$

The initial stock is chosen so that the ratio of the stock to GDP (in nominal terms) in the initial year is the same that in the last year of the sample, 23 percent. Over the period considered, the stock of durable goods amounts to 28 percent of measured GDP, on average, with a minimum of 23 percent in 2008 and a maximum of 35 percent in 1979.

Figure 1(a) shows the relative prices of equipment and structures. The base year is 1996. The relative price of structures increased by about 30 percent throughout the entire period 1960-2006. It is interesting to note that there were two previous booms: the price reached to 112.93 in 1979, and there was a minor surge in 1990, when the price rose to 106.30 prior to the peak in 2007, reaching the value 129.13. To put the numbers in context, we have calculated the relative price of residential structures in Spain and compare its evolution with the relative price reported by Davis and Heathcote (2007) for the US economy.[3] We have normalized the relative prices in the same manner so that 1996 is the base year for both. Figure 1(c) shows that both prices have a very similar evolution, being the peak in both countries in 2006; the price reaches 140 in Spain and 134.59 in the US.

Very different, though, is the behavior of the relative price of equipment. It exhibits a downwards trend, which we assume is due to the existence of ISTC. Figure 1(b) shows the relative price of business equipment in Spain and the US. We have taken the data for the US economy from Rodríguez-López and Torres (2012), who update the original series of Cummins and Violante (2002). As in the case of structures, the base year is 1996. It is interesting to note, although beyond the scope of this paper, that both prices have the same fluctuations implying that business cycles are very correlated. The fall in the relative price in the US is significantly higher in the US. This implies that ISTC and, *ceteris paribus*, measured TFP in the US, are higher than in Spain. The implied annualized growth rate of ISTC in business equipment for the period 1970-2008 has been

[3] We have used the data posted by the authors.

2.82 percent in Spain, whereas in the US has been 4.56 percent. We do not know why the relative price is different but our first candidate is the different sectoral composition of aggregate value added in US, where IT sectors must have a larger share than in Spain. Now we can turn to describe the aggregates that we have constructed consistently with our theory.

3.3 Aggregate measures consistent with our theory

As we argued in section 3, we need to augment measured GDP with the value of the services yielded by the stock of consumer durable goods. To do so, we proceed as Cooley and Prescott (1995) and compute the implicit rate of return to business capital and use that rate to estimate the implicit rate of return of the stock of durable goods. However, we have two types of capital. In our theory, the return of structures is distorted by subsidies. For this reason we use the implicit rate of return of business equipment to estimate that of durable goods. In Cooley and Prescott's theory, the relative price of capital is always one, whereas in our theory it is not. Thus, we need to take that into account. EU KLEMS gives information about capital compensation by type. We aggregate compensation of all types of business equipment. The ratio of this series to the stock of business equipment must be equal to $r_t^{bus\,equip}/q_t^{bus\,equip}$, according to our theory. Since we already have computed the relative price $q_t^{bus\,equip}$, we can apply a non arbitrage condition to calculate the implicit return to the stock of durable goods,

$$\frac{r_t^{bus\,equip} + (1-\delta^{bus\,equip})q_t^{bus\,equip}}{q_{t-1}^{bus\,equip}} = \frac{r_t^d + (1-\delta^d)q_t^d}{q_{t-1}^d}. \tag{3.4}$$

Our measure of output, Y_t, is measured GDP plus the value of the imputed services of consumer durable goods, $Y_t + r_t^d\, K_t^d$. Thus, output is, on average, 10.18 percent higher than measured GDP for the period 1970-2007. This value does not change much along the period. The minimum is 7.79 percent in 1970, it reaches a maximum of 14.37 in 1980 and its median value is 10.07 percent. This percentage is strikingly similar to that obtained for the US. See for instance, Prescott (1986). To obtain output in real terms we have divided the nominal measure by the deflator of non durable consumption and services.

Figure 1(d) shows the evolution of the capital to output ratio in Spain. Its mean for the period 1970-2007 is 3. To facilitate the analysis, we have also plotted the capital-output ratio for the US economy. As we see, the average in the US is about 2.5, about the same number computed by

other authors such as Prescott (1986) or Díaz and Luengo-Prado (2010). Thus, our economy is more capital intensive than the US. This difference is due to the stock of structures. Figure 1(e) compares the ratio of the stock of equipment to output in both economies. In Spain this ratio is about 0.71 for the entire period, although the mean of the ratio after 1996 is somewhat lower, 0.63. For the US the ratio fluctuates between 0.64 and 0.78 although it is consistently higher than its Spanish counterpart after 1985. Thus, the US is more intensive in equipment than Spain.

Let us now turn to structures. The picture is very different. Figure 1(f) shows the ratio of structures to output in both countries. In the US the average of this ratio is about 1.6 since it includes non residential structures. Its counterpart in Spain is much higher. As in the case of equipment, both ratios show similar time fluctuations. This Figure, coupled with Figure 1(c), implies that the difference between both countries comes from quantities, not prices (the size of non residential structures is small compared to residential structures). That is, the relative price of structures is similar in both countries but Spain invests much more in structures. To understand better the behavior of the capital to output ratio we also show in Figure 1(f) the evolution of the ratio of the stock of structures over output, K/Y. In the first ratio, $q\,K/Y$, capital is measured in units of non durable consumption. In the second ratio, K/Y, capital is in physical units. This ratio gives us a measure of structures intensity in the economy. Thus, capital intensity rises from 1.8 in 1970 to 2.4 in 1983 and has no trend thereafter. In particular, all the changes in the ratio $q\,K/Y$ observed since 1998 are due to changes in prices. Summarizing, the capital mix in Spain is biased towards structures. The business sector uses fewer machines than in the US. Also, those machines have lower quality (since their relative price declines more slowly than in the US). Moreover, the relative price of residential structures (which comprise the bulk of structures) is similar in both countries. Thus, Spain uses structures more intensively than the US. This conjecture is further confirmed when we inspect the investment ratio in Spain versus the US. Investment in equipment, as percentage of output, is fairly similar on both countries but, given the difference in relative prices, our economy invest less in equipment. The striking difference, though, is investment in structures. Taking into account that the relative price of this capital good is very similar in both countries we can conclude that Spain invests much more heavily in structures.

3.4 Calibration and solution method

The model economy is calibrated so that selected model statistics match their counterparts in the data for the period 1970-2007. The depreciation rates of equipment and structures, respectively, are directly calculated as weighted averages of the depreciation rates calculated in EU KLEMS for the corresponding categories comprised, respectively, in *Equipment* and *Structures*, as discussed in Section 3.2.

The elasticities of output with respect to equipment, α_e, and structures, α_s, are those for which the shares of each type of capital in our model economy are equal to the average of their counterparts in the data. EU KLEMS and BDMACRO report employees compensation. Both sources have some minor differences for the 1960s but they report essentially the same data. BDMACRO also reports Proprietors Income, which is called Mixed Income of Households in the Spanish National Accounts. We follow Cooley and Prescott (1995) to decompose Proprietors Income in capital and labor income. Figure 1(i) shows the labor, equipment and structures shares, respectively. The mean of the labor share for the entire period is 63.40 percent for the period 1970-2007. Prescott (1986) estimates it to be 64 percent for the US (he also imputes the value of consumer durable goods to aggregate output). The mean of the shares of equipment and structures are, respectively, 21.30 and 15.31 percent. For the sake of comparison, we also have depicted the share of labor in GDP, which is about 70 percent for the entire period considered. Greenwood et al. (1997) calibrate the factor shares for the US and report 17 percent and 13 percent, respectively. We should bear in mind that they do not include the stock of durable goods in the definition of equipment and, consequently, the share of labor is 70 percent. The breakdown in equipment and structures of the capital share is the same in their calibration and ours. Thus, $\alpha^e = 0.2130$, and $\alpha^s = 0.1531$. The fact that the share of equipment and structures in aggregate Value Added is the same in both economies, and the fact that durable services amount to 10 percent of GDP, imply that the weight of the durable stock is the same in both economies and that the observed differences in the ratio of the stock of equipment to output are due to lower business equipment in Spain.

The discount factor is chosen so that the average value of the equipment stock to output ratio is equal to 0.7073, as in the data. In order to choose a value for $\bar{h}$ in the utility function we follow the same approach that in Conesa et al. (2007) and set a constant value of $\bar{h} = 5200$. This value stands for the amount of hours which households are endowed with each year. The parameters ϕ and σ,

which govern the response of the labor supply to changes in income and wealth, are set so that the coefficient of variation and the mean of hours worked match the mean value of their counterpart in the data for the period 1995-2007. The weight of public consumption is set equal to one, $\eta = 1$. We have calibrated $\sigma = 0.2$, so that the model captures the increase in hours worked in the period 1996-2007. The value for ϕ is set so that the average number of hours worked comprise 19.45 percent of the available hours of working age people in Spain. We know that $\sigma < 1$ implies a very high intertemporal elasticity of substitution in leisure. This is the only way we have to capture the high volatility of the labor market in Spain. As we all know, the Spanish labor market is characterized by a high volatility in quantities (more so in the number of employees than in hours worked) and a high structural unemployment rate. The first feature of the labor market is captured in this very simple model by a low σ and the second feature is captured with a low value for ϕ. The Frisch elasticity is 20.7 in our benchmark model economy. We know that it is very high, but in models where the workweek is indivisible and there are employment lotteries (i.e., unemployment subsidy with contingent prices), the Frisch elasticity is infinite, see Rogerson (1988). We are mimicking a world close to that extreme.

Figure 1(h) shows the value of government expenditures as a fraction of output. This fraction has risen from less than 12 percent in 1970 to 20.58 in 1993, the through year of the recession prior to the Great Recession. It fell during the late 1990s and early 2000s and has climbed again to 20 percent in 2007. Figure 1(h) shows total government expenditures and the expenditures in goods and services. The difference between both measures shown is the value of the expenditures in public investment, I_t^g, which comprises about 2.6 percent of aggregate output. The value of government expenditures in goods and services is g_t in our theory and yields utility. We take the sequences of government expenditures as given and feed them into the model economy. Our benchmark model economy is a closed economy; therefore private consumption is aggregate output minus investment and government expenditures. We impute the trade balance to private consumption of non durable goods and services.

We need to calibrate a value for the sequence of subsidies to the return to structures, ξ_t. We will also refer to ξ_t as the "wedge", as it is common in the literature, (see Chari et al., 2007). We calculate a series for this wedge in the following way: we select the maximum wedge for which investment in structures, as percentage of output, is the same as in the data. This wedge summarizes all the market frictions that affect the return of structures. Government expenditures and the subsidy to

structures return are financed with lump-sum taxes. Table 1 summarizes the targets of the model economy and the implied values of the calibrated parameters. The series for neutral technical progress, Z_t, is obtained using a standard Solow decomposition.

Notice that we are not assuming that the Spanish economy is at a balanced growth path during the period 1970-2007. We are calibrating our benchmark model economy to match selected patterns of an economy in transition. Thus, we need to take a stand about the *beliefs* of our dynasty about the growth path of our model economy after 2007. We assume the following: neutral progress, Z_t, grows at the average growth rate of the period 1970-2007 after 2007. Population grows thereafter at its rate in 2007. The relative price of structures, q_t^s, is constant thereafter and equal to its value in 2007. The relative price of equipment, q_t^e, falls at the average rate of the previous period 1970-2007. Public expenditures, both consumption and investment, are constant as a fraction of output, and this ratio is that of 2007. Finally, we need to take a stand about the wedge in the return of structures, the subsidy. We assume that the wedge is the one needed for the ratio for structures to output, $q_t^s\, K_t^s/Y_t$, to be constant after 2007.

Solving for an equilibrium implies obtaining sequences of output, consumption, equipment, structures, and hours worked such that these sequences solve the system of equations, given initial conditions for the stock of equipment, k_0^e, and the stock of structures, k_0^s, and given sequences of the wedge in structures, ξ_t, government consumption, g_t, and government investment, I_t^g. Our numerical solution procedure follows Conesa et al. (2007) and a detailed explanation can be found in Appendix B.

4 The role of ISTC and subsidies in the Spanish growth experience

Here we discuss the ability of our model economy to replicate the observed growth patterns in Spain. In Section 4.1 we present our main results. Next, we run a series of counterfactual experiments incrementally. Section 4.2 shows the implications of eliminating subsidies to structures. In Section 4.3 we eliminate the subsidy and assume that the relative price of structures is constant over time. Next, in Section 4.4 we further assume that ISTC in equipment in Spain is as high as in the US. Section 4.5 quantifies the growth effects of additionally eliminating distortions in the labor market. Finally, in Section 4.6 we discuss the quantitative effects of a labor market reform in our benchmark economy.

It has been argued that the significant immigration flows experienced in Spain during the 2000s are responsible for the the strong growth in GDP observed during those years. In Section 4.7 we assess quantitatively the importance of this margin. Our benchmark economy is a closed economy. In Section 4.7 we quantify the bias introduced by ignoring this margin.

The way we proceed is the following: we feed into the model the initial stock of capital and the series of neutral technical progress, relative prices of capital, and the frictions considered. We keep the beliefs of the dynasty unaltered but for those that are part of the counterfactual exercise.

4.1 The benchmark

Figure 2 shows the results for our benchmark economy and compares the implied evolution of output, hours worked, aggregate capital and consumption in the model with the data. Figure 2(a) shows that output in our model economy evolves as output in the data. Table 2 shows the growth rate of output per worker in the data and the benchmark economy, for the entire period, 1970-2007, and three sub-periods corresponding to the three cycles that we observe in Spain during that entire period. We have used as through points the two troughs observed in hours worked per working age population in the data: 1985 and 1995. The first cycle ends in 1985. It started before 1970. The second cycle starts in 1985 and ends in 1995. The last one started in 1996 and has not finished yet. Table 2 also shows the decomposition of output growth according the procedure shown in (2.12). Table 3 shows the decomposition of TFP according to expression (2.15).

As shown in Table 2, the average growth rate of output per working age person, Y/N, has been 2.07 percent for the entire period in the data. Our benchmark economy delivers 2.53. It overestimates growth in the firs sub-period 1970-1985, 3.07 versus 1.39 percent. The reason is that hours worked drop in the model in 1970 and shot up afterwards, whereas they fall in the data. As a consequence, growth is higher in the model economy than in the data. For the sub-period 1986-1995, the average growth rate in the data was 1.81 and the model delivers 1.68. During the last period the average growth rate in the data was 2.52 percent and in the model economy is 1.98. Overall, we think that our model economy captures the main features of output in Spain for the entire period.

Let us turn to Table 3 where we show the growth rate of TFP for the aforementioned periods. Recall that measured TFP depends on the evolution of the capital mix of the economy out of the

balanced growth path. Our theory does a good job capturing the changes in TFP growth rate for all the period. For the sub-period 1996-2007, the growth rate of measured TFP in the data is 0.01 percent, whereas is -0.10 percent in the model economy. This is due to the fact that the structures to output ratio increases more rapidly in the model than in the data during the first part of the period 1996-2007.

Hours worked in the model economy have a high variance, as in the data, as shown in Figure 2(b). We could not capture the entire variance of hours worked but we are able to capture a significant fraction of the observed variance in the two previous recessions in Spain, the 1980s and the early 1990s. Figure 2(c) shows the evolution of the ratio of the equipment stock to output. Our model economy cannot capture the downwards trend in the ratio, but it reproduces well the spikes corresponding to the peaks of the business cycles experienced in Spain. Figure 3(e) shows the ratio of structures to output, which is matched fairly well since we have calibrated it. Next, 2(e) shows the evolution of private consumption in the model economy and the appropriate counterpart in the data. Recall that our benchmark model economy is a closed economy. We have imputed the trade balance to current private consumption of non durable goods. Thus, we conclude that our model economy replicates reasonably well the growth experience of Spain for the period 1970-2007.

Finally, Figure 2(f) shows the subsidy to structures as percentage of output. Notice that once calibrated the wedge, ξ_t, the subsidy as percentage of output is $\xi_t\,\alpha^s$. The average is 12.09 percent of output. That is, the return to structures after taxes doubles its return before taxes. The average subsidy is 80 percent. This subsidy to the return is roughly equivalent to a subsidy to the purchase of structures of 55 percent of their market price. We also report in Figure 2(f) the implicit subsidy present in the data. Recall that we have information about compensation to structures and equipment in the data, information that was used to calibrate the factor elasticities of output, α^e and α^s. The compensation to capital is just $r_t^i\,K_t^i$, $i = e,\, s$, before taxes. Using the non arbitrage condition shown in (2.10) we can compute a series for $\widetilde{\xi}_t$, the subsidy needed to equate the real return of both types of capital in the data. The subsidy as percentage of output is $\widetilde{\xi}_t\,\alpha^s$. Notice that both subsidies, that implied by the data and the model have the same magnitude. We know that this subsidy is very high but we should take into account that it is financed with lump-sum taxes. If it had been financed with taxes that distorted the return to equipment and/or labor, its size would have been lower. García-Montalvo (2012) estimates that the fiscal benefits associated to the purchase of first residence amount to a subsidy of about 10 and 20 percent of the housing

price. These benefits amount to 1 percent of GDP during the 1990s and 2000s. In our case, this subsidy not only comprises direct subsidies to residential investment but also any type of subsidy to firms in the construction sector and any activity intensive in structures as, for instance, tourism and privately managed infrastructures (i.e, highways). Gravelle (2011) estimates the effective tax rates on business equipment and structures for different types of investment goods in the US economy. These effective tax rates measure the estimated share of the return that is collected in taxes. For instance, the effective tax rate on communications equipment is 19 percent, whereas the return of industrial structures is effectively taxed at 37 percent. That is, equipment has an implicit subsidy since it has a lower effective tax. A similar study for Spain would be needed to go beyond our aggregate estimates. There is also anecdotal evidence that point out to huge implicit subsidies to structures in the sector of construction of infrastructures: highways. In any case, it is left for further research estimating directly the true direct and indirect subsidies given to structures in Spain through the structure of the Corporate Income Tax.

4.2 The quantitative effect of eliminating subsidies to structures

Now we move to examine the economy in which there are no subsidies to the return to structures. Thus, we set $\xi_t = 0$, for 1970 onwards, including the years after 2007. For the sake of simplicity we have labeled this economy as the *no wedge* economy. The economy is simulated assuming that it starts with the same level of capital that the benchmark and the data. Thus, differences in output in the first period come from hours worked. We should note that the *no wedge* economy is efficient (conditional to the level of public expenditures), since there are no distorting taxes.

Figure 3 shows the results for our benchmark economy and compares the implied evolution of output, hours worked, aggregate capital and consumption with the data and the benchmark economy. For illustrative purposes, we also report results for another economy labeled *one sector* economy. In this economy, aggregate output is produced with the technology shown in (2.14) and capital is produced with a one to one technology. The series of Total Factor Productivity (TFP hereafter), A_t, is obtained by a standard Solow decomposition procedure and it is shown in Figure 3(g) along with the level of neutral technical progress, Z_t. We keep the same calibration in both economies.

As we can see in Figure 3(a), output (in light blue) stagnates during the 2000s. The average

growth rate of output per worker in the period 1996-2007 is 0.48, whereas it was 1.98 in the benchmark economy, as shown in Table 2. The average growth rate of income for the entire period 1970-2007 is 0.90 versus 2.53 in the benchmark model economy and 2.07 percent in the data. Thus, two thirds of the income growth observed in our benchmark economy are due to the presence of subsidies. For the entire period 1970-2007 the fraction is about the same: 64 percent of the average growth rate is due to subsidies. Taking this economy at face value and comparing it to the data, income growth without subsidies would have been 20 percent of the observed figure for the period 1996-2007 and 43 percent of the average growth rate for the entire period 1970-2007. This counterfactual exercise implies that most growth is due to inefficiently high investment in structures, as confirmed by Figures 3(c), 3(d), and 3(e). Investment in structures plummets in absence of subsidies. The ratio of equipment to output is not much affected. If the subsidy had been financed with distortionary taxation we would have seen a change in its after-tax return, and therefore in this ratio. Thus, since ISTC embodied in equipment is low, the economy grows little compared to the data. Likewise, hours worked (see Figure 3(b)) fall, in particular during the period 1996-2007. Thus, our theory suggests that the growth in hours worked experienced during that period is due to the inefficiently high investment in structures that raises marginal productivity of labor.

Looking at the row labeled BGP in Table 2 we can see that the growth rate of output per worker in the *no wedge* economy is the same that in the benchmark economy at the balanced growth path. This so because in both economies we have the same assumptions about neutral progress and ISTC. Moreover, both economies have transitions of very approximate length: in both economies output per worker in 2007 is about 99 percent of its balanced growth path value. In 2007, output per worker in the *no wedge* economy is 73 percent of its counterpart in the benchmark economy. That is, the *no wedge* economy settles in a lower balanced growth path. That is, subsidies have a level effect on output, not a growth rate effect. Now we can turn to Table 3 where we report measured TFP. The differences in measured TFP between our benchmark economy and the *no wedge* economy steam from the different composition of capital. For the entire period 1970-2007, the existence of subsidies lower TFP from 1.17 to 0.98 percent, a fall of 16 percent. We need to emphasize that the TFP growth rate is the same in the balanced growth path of both economies, because the subsidy is constant in the balanced growth path and the capital mix does not change.

Finally, Figure 3 shows that the *one sector* economy behaves very similarly to the *no wedge*

economy. Thus, we could use this one sector growth model to argue that investment is inefficiently high in Spain but it gives us no clue about the sources of low TFP. Our three sector model economy allows us to identify them.

4.3 The gains of eliminating subsidies and price booms

Now we eliminate from our *no wedge* economy fluctuations in the relative price of structures. Thus, we assume that $q_t^s = q > 0$, the average for the entire period 1970-2007. There are many reasons why the relative price of structures change over time. In particular, the literature has emphasized the easing of financial conditions that implied a credit boom (see Franjo, 2014) or the cyclical effect of search frictions (see Díaz and Jerez, 2013). Here we want to measure the effect of such fluctuations by imposing a constant price. According to Davis and Heathcote (2005) the relative price of structures have a slight trend upwards, but is very small, so we abstract from it and, as Greenwood et al. (1997), we assume that it is always constant. For the sake of simplicity we have labeled this economy as the *no boom* economy.

Figure 4 shows the behavior of output, hours worked, the capital output ratio and consumption in this case. The main differences between this economy and the *no wedge* come from the the fact that in the previous economy investment in structures rises in the period 1996-2007 because of the increase in the price of structures, whereas here there is not such a increase. This is why the structures to output ratio is smaller in this economy after 1995. Since the price of structures does not increase, the economy is more productive, which implies an average growth rate of output per worker of 1.41 percent, as opposed to 0.90 percent, for the entire period 1970-2007, as shown in Table 2. The reason is that the average growth rate of TFP in the *no boom* economy is 60 percent higher than in the *no wedge* economy: 1.87 versus 1.17 percent. In the long run, though, both economies are very similar since we have assumed a constant price of structures in the balanced growth path. In this economy, as in the *no wedge* economy, output per worker in 2007 is about 70 percent of output per worker in the benchmark economy. In other words: eliminating subsidies to structures increase productivity but lower the level of output. The reason being that the economy without subsidies invest much less than the benchmark economy. The further elimination of price fluctuations rise TFP but does not affect significantly output. Next, we ask ourselves: What rate of ISTC in equipment generates output growth as seen in the data? We answer this question in the following Section.

4.4 The effect of low ISTC in equipment

In order to illustrate the importance of ISTC we take the relative price of business equipment of the US and feed it into the model economy without subsidies and a constant relative price of structures. We proceed in the same spirit of Chen et al. (2006), but instead of taking the TFP of the US, we just take as given the US relative price of business equipment, given the differences observed with respect to Spain (see Figure 1(b)) and because of its clear economic meaning. We label this economy the *US price* economy. This exercise is meant to capture the effects of a change in sectoral composition in Spain. If the sectors where ISTC is high grew in percentage of aggregate Value Added, this would be reflected in the relative price of equipment as an acceleration in its fall over time. Figure 5 shows the evolution of output, hours worked, capital and consumption in this economy. Notice that output starts below the benchmark (see Figure 5(a)). This is so because hours worked remain well below the benchmark and the data, as shown in Figure 5(b). The equipment to output ratio also falls with respect to the benchmark economy, as shown in Figure 5(c). The structures to output ratio is also very low. That is, the higher ISTC produces an income effect so that households invest less and work fewer hours than in the benchmark economy and the *no boom* economy. Notice the upwards trend in hours worked, though. This is the response to the acceleration in ISTC in equipment.

Overall, in spite of high ISTC, the level of output per worker in 2007 in this economy is the same that in the benchmark economy. This is due to the fact that hours worked are very low. The main difference between this economy and the *no wedge* economy and the *no boom* economy, is that hours worked have a slight upward trend in this case during the entire period 1970-2007. Otherwise, they remain below 18 percent of available time and are low, even decreasing for the sub period 1996-2007. Only the benchmark economy features increasing hours worked for the period 1996-2007, which suggests that the upsurge in hours worked witnessed in that period in Spain is mostly due to the high investment in structures. Output per worker in the *US price* economy is below its counterpart in the benchmark until the late 1980s, moment after which the *US price* economy starts growing at a higher rate and reaches a balanced growth path with a higher growth rate, 3.16 percent versus 2.23 percent. Table 3 shows the TFP decomposition in this case. The main lesson that we extract from this counterfactual economy is that the key factor determining TFP is investment specific technical change. In an economy with high ISTC, as the US, TFP is higher. The second lesson is that in this economy, hours worked fall since they are substituted away by equipment. Thus, rising ISTC will not bring an increase in hours worked.

4.5 Adding a not distorted labor market

One striking feature of the *US price* economy is the behavior of hours worked. They are very low, less than 15 percent of available hours and rise to be around 18 after the late 1980s. This is very far from the usual 33 percent of the time typically assumed in standard calibration exercises. This is so because we have assumed a large Frisch elasticity, 20, and a high value of leisure. This calibration can be thought of a reduced way of capturing the effect of labor market distortions: a fixed workweek, unemployment subsidies and labor taxes. It is beyond the scope of this paper to study why average hours worked are lower in Spain than in the US (see Conesa and Kehoe, 2005; Prescott, 2004) but we can quantify the effect of a labor market reform. Suppose that all labor market distortions are eliminated so that the dynasty works, on average, one third of its available time. Suppose, further, that creation and destruction of jobs is so smooth that fluctuation of hours worked is very small. The effect of such a reform will show up as high average hours worked with little fluctuations over time. To mimic this economy, utility parameters are recalibrated so that the dynasty works, on average for the entire 1970-2007 period, one third of its time. Moreover, we assume $\sigma = 1$, which implies that the Frisch elasticity is 3 instead of 20. We have labeled this economy the *US market* economy. Figure 6 shows the evolution of output, hours worked, capital and consumption in this economy. Tables 2 and 3 show that this economy is very close to the *US price* economy. There two main differences. First, the behavior of hours worked, which are higher throughout the entire period 1970-2007 in the *US market* economy; and second, consumption booms. In the *US market* economy consumption, as fraction of output, is significantly higher. The growth rate of output per worker at the balanced growth path is the same, but the level of output is higher in the *US market* economy. Thus, a labor market reform reduces investment as percentage of GDP.

4.6 A labor market reform in the benchmark model economy

The previous economy implies that average hours worked affects the level of output per worker at the balanced growth path. Thus, we want to assess here the effect of such labor market reform in our benchmark model economy. To do so, we change the utility function in our benchmark model economy, keeping the subsidy to structures, and the relative price of capital goods observed in the Spanish data. The growth patterns of this counterfactual economy are shown in Figure 7. This economy is labeled *LMR* in Tables 2 and 3. Notice that by 2007, output per worker is 1.65 times

that observed in the data, whereas the benchmark delivers a ratio of 1.02. As shown in Table 2 the growth rate of output per worker is a bit higher than in the benchmark, 2.71 versus 2.53 percent for the entire period 1970-2007. Table 3 shows that a labor market reform produces negligible gains in TFP during the transition 1970-2007 and there are none at the balanced growth path, since hours worked are constant in the balanced growth path. The effect of a labor market reform is a level effect. Thus, in absence of other policy measures that boost adoption of new technologies and ISTC, as also noted by Bentolila et al. (2012), a labor market reform does not increase TFP in the long run, although it has a a significant effect on the level of output.

4.7 International borrowing and lending and population growth

In our previous exercises we have assumed that Spain is a closed economy, which is clearly not. Here we want to assess the bias in which we incur by assuming a closed economy. Figure 8(a) shows net exports in Spain as percentage of our measure of output. Net exports are negatively correlated with output and its fluctuations have increased after Spain adopted the euro. In particular, we have been running a deficit since mid 1990s. Here we conduct the following exercise. We take as given the trade balance as percentage of output and set the time series for the interest rate on the internationally traded bond so that, in fact, our benchmark economy has a trade balanced as observed in the data. In this new economy the trade balance is no longer imputed to private consumption. As for the subsidy, we proceed as in our benchmark economy and we keep all the assumptions about the relative price of capital goods and government expenditures along the balanced growth path. We need to add the beliefs of the dynasty about the future trade balance and the volume of international borrowing and lending. In an exercise close to that conducted by Kehoe et al. (2013), we assume that there is a gradual rebalancing of the current account until the economy reaches its balanced growth path, which happens in 2018. During the transition, the current account, as percentage of output, mirrors backwards (symmetrically), the size of the current account in Spain from 2007 to 1997, year in which there was a surplus.

Figure 8 shows the evolution of output, hours worked and private consumption plus the trade balance as percentage of output. Thus, we think that our closed economy is a good approximation of this open economy. Figure 8(e) shows the interest rate of the internationally traded bond along the period 1970-2007. On average, its return is very high compared to real interest rates in Spain, specially during the period 1996-2007. Notice that we have calibrated the discount factor so that the

average equipment to output ratio in our benchmark economy matches its counterpart in the data. That implies a discount factor somewhat low for annual terms, 0.9126, but we should keep in mind that we have abstracted from distortionary taxation that lowers the after tax return of capital. The important thing, though, is that the implied interest rate has a downward trend, which is consistent with the evidence in Spain.

Finally, some authors have argued that the immigration boom experienced in Spain during the period 1996-2007 is related to the high growth in output observed during that period (see Bentolila et al., 2008). To measure the contribution of immigration to growth during the period 1996-2007, we conduct the following counterfactual experiment: we build an alternative economy where the growth rate of the dynasty after 1995 is the average of the previous period. The only effect is that hours worked are lower. The rest of the variables, output, consumption, and capital-output ratios all remain unchanged. Table 2 show that average output growth would have been 1.61 percent instead of 1.91 during the period 1996-2007, 19 percent lower. Thus, immigration had a non negligible effect on income growth in that last subperiod.

5 Barriers to growth?

The previous analysis of the Spanish economy lead to two questions. (1) Why structures are so heavily subsidized and (2) why ISTC is so low in Spain. Both features together act as a barrier to growth. Here we want to discuss a bit the particular features of the Spanish economy that may give us some insights about the nature of those subsidies and the sources of low ISTC.

Recall that the subsidy calibrated in our benchmark model economy is an upper bound since we have assumed that there is distortionary taxation. Moreover, it captures all market distortions that increase the return to structures. As we argued in Section 4.1, to the best of our knowledge there are no direct measures of the subsidies given to structures beyond the estimates calculated by García-Montalvo (2012). Thus, some research on the matter would be needed to estimate the direct subsidies given to structures. Santos (2014) analyzes the role played by the *Cajas* in the observed credit boom in Spain during the period 1996-2007. *Cajas* are non-profit commercial banks. Their particular system of governance was designed to provide financial services to the poor and underprivileged, but made them very easy to control by regional governments and circumvent any supervision from the Bank of Spain. By 2007, the *Cajas* accounted for 50 of total financial

credit given in Spain and half of all bank deposits. The expansion of credit that occurred during that period came with a lowering of standards that can be counted as an implicit subsidy. In 2007 almost 50 percent of the loans by credit institutions in Spain were going to construction companies and real estate developers. Recent literature has tried to account quantitatively for the boom in house prices, (see, for instance, Díaz and Jerez, 2013) or Franjo (2014). This literature abstract form any type of intervention. For instance, a very typical form of intervention in the construction sector was subsidizing the construction of public housing, which were sold at a regulated price, the so called in Spanish, "Viviendas de Protección oficial". This policy meant, in reality, putting a floor to the housing price, and has been an indirect way of subsidizing the construction sector.

This analysis has stressed the importance of low ISTC for understanding the observed low TFP growth in Spain. Figure 10(a) shows the evolution of measured TFP for the different model economies studied. The picture clearly shows that what makes a difference is high ISTC. Why is ISTC so low in Spain? The evidence reported by Mas and Robledo (2010) suggests that sectoral composition in Spain must be partly responsible of it. For instance, in 2012 tourism accounted for 10.9 percent of aggregate Value Added and construction accounted for 10 percent of aggregate Value Added in 2010. Both are activities intensive in low-skilled labor. Nevertheless, as Mas and Robledo (2010) report, low TFP affects all sectors in Spain. Two reasons might be important to understand why this is the case. The first one is the firm size distribution. Pagano and Schivardi (2003) use data on manufacturing firms of eighteen European countries and find that the Spanish firms are, on average, a size equivalent to 58 percent of the EU-15 average. Among the large European countries, only Italy features a lower average firm size, 42 percent. According to Fernández de Guevara (2012), TFP in large firms is 15 percent higher than in smaller firms in Spain. Moreover, private expenditures in R&D are very small in Spain. López-García and Montero (2010) report that private expenditure in R&D activities in Spain in 2008 was 0.6 percent of GDP, whereas it was 1.2 percent in EU15 and 1.9 percent in the US. Moreover, according to the *The 2009 EU Industrial R&D Investment Scoreboard* only 21 Spanish companies are included in the ranking of the top 1000 R&D European firms, and their combined R&D spending amounts barely to 1 percent of the total private R&D spending within the EU. These figures compare poorly with the 247 British firms in the ranking, which represent together about 15 percent of total private R&D in the EU, 209 German ones, which account for more than one-third of R&D, or the 70 Swedish firms accounting for 5 percent of total EU R&D. Why this is the case, again, might be related to sectoral composition and barriers to entry that reduce incumbent incentives to innovate. On the later instance, Alonso-

Borrego (2010), using data from Balance Sheets of the Bank of Spain, a sample of the entire universe of firms in Spain, shows that the lack of competition deters firms from using more innovative and cost-reducing production techniques.

Fernández de Guevara (2012) also rises a point related to Alonso-Borrego (2010): dispersion of productivity within sectors is much higher than dispersion across sectors. Moreover, reallocation of resources across firms is very low in Spain, consistently with the evidence reported by Bartelsman et al. (2013) for a cross-section of countries. This suggests that lack of competition may be responsible of misallocation of resources, which might be at the heart of low ISTC in Spain.

6 Final comments

Spain is an economy with low Total Factor Productivity which is able to sustain high GDP growth. To study this puzzling behavior of the Spanish economy we have built a model economy along the lines of Greenwood et al. (1997) with two types of capital: equipment and structures. We apply the methodology of Kehoe and Prescott (2002) to study the growth patterns of Spain during the period 1970-2007. A key feature of our quantitative study is that we are able to quantify the direct and indirect subsidies given to the return of structures. We calculate that the after tax effective return of structures is doubled. The measure of our subsidy is a composite of direct and indirect subsidies and market distortions that rise the return of structures. Thus, given the size of the subsidy, the economy investment rate is inefficiently high, which allows to sustain an income growth rate as observed in the data. Since structures are less productive than equipment (it has no ISTC embodied), this policy feeds back into lower TFP through changes in the capital mix used for production. Moreover, our benchmark model economy suggests that the upsurge of hours worked observed during the period 1996-2007 is entirely due to the rise in investment in structures, which increase marginal productivity of labor. Hours drop as soon as subsidies are eliminated. The boom in the relative price of structures eat up 0.52 percent of the average growth rate in the period 1996-2007. This fact is interesting since there are other countries that have suffered a house price boom during the same period that Spain. We leave for further research to measure the effect of that price rise on measured TFP in other countries.

The source of low TFP is the combination of low ISTC in equipment and the upsurge in the relative price of structures. According to our theory, in absence of those subsidies, growth in output

per worker during the period 1996- 2007 would have been less than half of the growth observed. We also show that the the key element to sustain a high growth rate of output and TFP is high ISTC. It is difficult to assess what the growth rate of ISTC should be. In our counterfactual exercise, we assume that ISTC in Spain grows at the same rate than in the US and, not surprisingly, our counterfactual economy displays an income growth rate similar to that of the US, 3 percent. We are not capturing all the effects of high ISTC. For instance, there is no accumulation of human capital in our theory. Since ISTC has strong complementarities with human capital, (see Krusell et al., 2000), higher ISTC must affect the return to human capital and the skill premium. We cannot assess in this paper why ISTC is so low in Spain. The literature points to three features of the Spanish economy: the sectoral composition, the small size of the average firm and low expenditures in R&D. More research is needed to design policies intended to foster growth in TFP in Spain.

A Existence of the balanced growth path in the closed economy

The following set of equations characterize the equilibrium of this economy:

$$H_t: \quad w_t - (1-\alpha^e-\alpha^s)\, Z_t\, (K_t^e)^{\alpha^e}\, (K_t^s)^{\alpha^s}\, H_t^{-\alpha^e-\alpha^s} = 0, \tag{A.1}$$

$$K_t^e: \quad r_t^e - \alpha^e\, Z_t\, (K_t^e)^{\alpha^e-1}\, (K_t^s)^{\alpha^s}\, H_t^{1-\alpha^e-\alpha^s} = 0, \tag{A.2}$$

$$K_t^s: \quad r_t^s - \alpha^s\, Z_t\, (K_t^e)^{\alpha^e}\, (K_t^s)^{\alpha^s-1}\, H_t^{1-\alpha^e-\alpha^s} = 0, \tag{A.3}$$

$$c_t: \quad \beta^t\, N_t\, \frac{1}{c_t+\eta\, g_t} - \lambda_t = 0, \tag{A.4}$$

$$h_t: \quad -\beta^t\, N_t\, \phi\, (\hbar - h_t)^{-\sigma} + \lambda_t\, w_t = 0, \tag{A.5}$$

$$k_{t+1}^e: \quad -\lambda_t\, q_t^e(1+n) + \lambda_{t+1}\, \left((1-\delta^e)\, q_{t+1}^e + r_{t+1}^e\right) = 0, \tag{A.6}$$

$$k_{t+1}^s: \quad -\lambda_t\, q_t^s(1+n) + \lambda_{t+1}\, \left((1-\delta^s)\, q_{t+1}^s + (1-\tau_{t+1})\, r_{t+1}^s\right) = 0, \tag{A.7}$$

$$c_t + q_t^e\, x_t^e + q_t^s\, x_t^s + g_t + i_t^g = y_t. \tag{A.8}$$

From (A.4), (A.6), and (A.7) we obtain:

$$\beta\left[\frac{1-\delta^e}{1+\theta^e} + \frac{r_{t+1}^e}{q_t^e}\right] = \frac{c_{t+1}+\eta\, g_{t+1}}{c_t+\eta\, g_t}, \tag{A.9}$$

$$\beta\left[\frac{1-\delta^s}{1+\theta^s} + \frac{(1-\tau_{t+1})\, r_{t+1}^s}{q_t^s}\right] = \frac{c_{t+1}+\eta\, g_{t+1}}{c_t+\eta\, g_t}, \tag{A.10}$$

and from (A.4) and (A.5),

$$(\hbar - h_t)^\sigma = \phi \frac{c_t+\eta\, g_t}{w_t}. \tag{A.11}$$

To solve for the balanced-growth path, we make use of equations (A.9) and (A.2) to solve for the equipment-output ratio, $\frac{q_e k_e}{y}$:

$$\frac{q_e k_e}{y} = \frac{\alpha_e}{\frac{(1+g_y)(1+\theta^e)}{\beta} - (1-\delta^e)}. \tag{A.12}$$

since consumption and government consumption grow at the rate of final output. Assuming that along the balanced-growth path taxes (or subsidies) on the return to structures are constant, we use (A.10) and (A.3) to solve for the structures-output ratio, $\frac{q_s k_s}{y}$:

$$\frac{q_s k_s}{y} = \frac{(1-\tau)\, \alpha_s}{\frac{(1+g_y)(1+\theta^s)}{\beta} - (1-\delta^s)}. \tag{A.13}$$

We then use (A.1) and (A.8) to rewrite (A.11) as:

$$(1-\alpha_e-\alpha_s)\, \frac{(\hbar-h)^\sigma}{h} =$$

$$= \phi\left[1 - ((1+n)(1+g_y)(1+\theta^e) - 1 + \delta^e)\, \frac{q_e k_e}{y} - ((1+n)(1+g_y)(1+\theta^s) - 1 + \delta^s)\, \frac{q_s k_s}{y} - (1-\eta)\frac{g}{y} - \frac{i^g}{y}\right]. \tag{A.14}$$

and use this equation to obtain hours worked along the balanced-growth path, h. It is easy to check that the inverse of the Frisch elasticity of hours worked, ϵ^h is

$$\left(\varepsilon^h\right)^{-1} = \sigma\,\hbar^{1-\frac{1}{\sigma}}\left[\left(\frac{h_t}{\hbar}\right)\left(\frac{\phi\left(c_t+\eta\,g_t\right)}{(1-\alpha^e-\alpha^s)y_t}\right)\right]^{\frac{-1}{\sigma}} - 1 \tag{A.15}$$

B Numerical Solution Procedure

We follow the method employed in Conesa et al. (2007). We assume that the economy starts at some T_0 and converges to its balanced-growth path at some, large enough, T_1. Then, we need to choose $k^e_{T_0+1}, k^e_{T_0+2}, ..., k^e_{T_1}$, $k^s_{T_0+1}, k^s_{T_0+2}, ..., k^s_{T_1}$, and $h_{T_0}, h_{T_0+1}, ..., h_{T_1}$ to satisfy:

$$(1-\alpha_e-\alpha_s)Z_t(k^e_t)^{\alpha_e}(k^s_t)^{\alpha_s}h_t^{-\alpha_e-\alpha_s}(\bar{h}-h_t)^{\sigma} = \phi\left(c_t+\eta g_t\right), \tag{B.1}$$

$$\frac{\beta}{q^e_t}\left[(1-\delta^e)q^e_{t+1}+\alpha_e Z_{t+1}(k^e_{t+1})^{\alpha_e-1}(k^s_{t+1})^{\alpha_s}h_{t+1}^{1-\alpha_e-\alpha_s}\right] = \frac{c_{t+1}+\eta g_{t+1}}{c_t+\eta g_t}, \tag{B.2}$$

$$\frac{\beta}{q^s_t}\left[(1-\delta^s)q^s_{t+1}+\alpha_s(1-\tau_{t+1})Z_{t+1}(k^e_{t+1})^{\alpha_e}(k^s_{t+1})^{\alpha_s-1}h_{t+1}^{1-\alpha_e-\alpha_s}\right] = \frac{c_{t+1}+\eta g_{t+1}}{c_t+\eta g_t}, \tag{B.3}$$

where:

$$c_t = Z_t(k^e_t)^{\alpha_e}(k^s_t)^{\alpha_s}h_t^{1-\alpha_e-\alpha_s} - q^e_t\left((1+n)k^e_{t+1}-(1-\delta^e)k^e_t\right) - q^s_t\left((1+n)k^s_{t+1}-(1-\delta^s)k^s_t\right) - g_t - i^g_t,$$

In this system, (B.1) is defined for $t = T_0, T_0+1, ..., T_1$, and (B.2) and (B.3) for $t = T_0, T_0+1, ..., T_1-1$. For a given sequence of the wedge in structures $\tau_{T_0+1}, \tau_{T_0+2}, ..., \tau_{T_1}$, for government consumption $g_{T_0}, g_{T_0+1}, ..., g_{T_1}$, and government investment $i^g_{T_0}, i^g_{T_0+1}, ..., i^g_{T_1}$, this problem requires solving $3(T_1-T_0)-2$ equations in $3(T_1-T_0)-2$ unknowns. To this end, we use the Newton's method to solve the system of equations. Define the stacked vector of variables $x = [k^e_{T_0+1}, k^e_{T_0+2}, ..., k^e_{T_1}, k^s_{T_0+1}, k^s_{T_0+2}, ..., k^s_{T_1}, h_{T_0}, h_{T_0+1}, ..., h_{T_1}]'$ and arrange the system of equations so that they are of the form $f(x) = \overline{0}$, where $\overline{0}$ is a $3(T_1-T_0)-2$ vector of zeros. The algorithm involves making an initial guess at the variables, x^0, and updating the guess by $x^{i+1} = x^i - Df(x^i)^{-1}f(x^i)$, where $Df(x^i)$ is the matrix of partial derivatives of $f(x)$ evaluated at x^i. The system of equations does not have closed-form expressions for the partial derivatives needed to compute $Df(x^i)$, and so the derivatives have to be evaluated numerically. A solution is obtained when the function, evaluated at the new iterate of x, has a maximum error less than some value ε, where ε is a small number. Although this method of solving a system of nonlinear equations can converge to a solution quickly, this method is not globally convergent and can become stuck away from a zero of $f(x)$ or may not converge at all. The initial guess, x^0, is important.

To increase the probability of the algorithm converging to the correct answer, we solve a sequence of models, beginning with a simple version of the model, which we know how to solve, and progressing to the model that we would like to solve. The first model we solve is the one in which Z_t, the relative price of equipment, the wedge in structures, the population, and available hours are constant and equal to their average values from 1973 to 2007. The solution to this problem is relatively easy to find. The next model takes Z_t, the relative price of equipment, the wedge in structures, the population, and available hours, to be convex combinations of the constant values used in the initial model and the actual values from the data. Let λ be the weight on the constant values, so that $(1-\lambda)$ is the weight on the values from the data. The algorithm requires repeatedly decrementing

λ and solving the resulting model, each time using the solution to the model before it as the initial guess. The algorithm proceeds until it solves the case in which $\lambda = 0$, which corresponds to the model whose solution I desire. If the value of investment becomes negative in some period t, we replace the corresponding equation (B.2) or (B.3) with equations:

$$k^e_{t+1} = \frac{(1-\delta_e)}{(1+n)} k^e_t, \tag{B.4}$$

$$k^s_{t+1} = \frac{(1-\delta_s)}{(1+n)} k^s_t, \tag{B.5}$$

respectively. As we change λ, we check that the inequalities:

$$\frac{c_{t+1} + \eta g_{t+1}}{c_t + \eta g_t} \geq \frac{\beta}{q^e_t} \left[(1-\delta^e) q^e_{t+1} + \alpha_e Z_{t+1} (k^e_{t+1})^{\alpha_e - 1} (k^s_{t+1})^{\alpha_s} h^{1-\alpha_e-\alpha_s}_{t+1} \right],$$

$$\frac{c_{t+1} + \eta g_{t+1}}{c_t + \eta g_t} \geq \frac{\beta}{q^s_t} \left[(1-\delta^s) q^s_{t+1} + \alpha_s (1-\tau_{t+1}) Z_{t+1} (k^e_{t+1})^{\alpha_e} (k^s_{t+1})^{\alpha_s - 1} h^{1-\alpha_e-\alpha_s}_{t+1} \right],$$

hold. If they do not, we replace the corresponding (B.4) with (B.2), or (B.5) with (B.3), respectively.

Param.	Observation			Value
	The benchmark economy			
β	$q_e\, K_e/Y$	=	0.7073	0.9126
ϕ	Mean of H/N	=	0.1945	0.0047
σ	CV (1995-2007) of H/N	=	0.0132	0.2000
α_e	$r_e\, K_e/Y$			0.2130
α_s	$r_s\, K_s/Y$			0.1531
δ_e	Weighted average in EU KLEMS			0.1645
δ_s	Weighted average in EU KLEMS			0.0130

Notes: The targets are annual averages for the period 1973-2007.

Table 1: Aggregate targets

		Data	Benchmark	No Wedge	No Boom	US Price	US Market	No Pop	LMR
1970-2007	y	2.07	2.53	0.90	1.41	2.84	3.14	-	2.71
	Z	1.58	1.58	1.58	1.58	1.58	1.58	-	1.58
	q_e	0.64	0.64	0.64	0.64	1.56	1.56	-	0.64
	q_s	-0.24	-0.24	-0.24	0.00	0.00	0.00	-	-0.24
	$q_e\, k_e/y$	-0.26	-0.32	-0.05	-0.27	-0.41	0.01	-	0.06
	$q_s\, k_s/y$	0.43	0.32	0.16	-0.25	-0.46	-0.16	-	0.60
	h	-0.08	0.53	-1.17	-0.29	0.57	0.13	-	0.04
1970-1985	y	1.39	3.07	0.11	1.31	2.75	3.43	-	3.70
	Z	2.74	2.74	2.74	2.74	2.74	2.74	-	2.74
	q_e	0.42	0.42	0.42	0.42	1.24	1.24	-	0.42
	q_s	-0.21	-0.21	-0.21	0.00	0.00	0.00	-	-0.21
	$q_e\, k_e/y$	-0.30	-0.77	-0.14	-0.56	-1.38	-0.34	-	0.09
	$q_s\, k_s/y$	0.65	0.24	0.16	-0.34	-1.13	-0.61	-	0.86
	h	-1.87	0.63	-2.79	-0.93	1.31	0.40	-	-0.24
1986-1995	y	1.81	1.68	2.19	1.77	2.67	2.79	-	1.86
	Z	0.95	0.95	0.95	0.95	0.95	0.95	-	0.95
	q_e	0.53	0.53	0.53	0.53	1.62	1.62	-	0.53
	q_s	0.03	0.03	0.03	0.00	0.00	0.00	-	0.03
	$q_e\, k_e/y$	-0.09	0.49	0.59	0.56	0.07	0.09	-	0.48
	$q_s\, k_s/y$	0.08	0.11	-0.70	-0.55	0.09	0.28	-	0.10
	h	0.30	-0.44	0.78	0.27	-0.08	-0.18	-	-0.25
1996-2007	y	2.52	1.98	0.48	0.93	2.26	2.30	1.62	1.61
	Z	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17
	q_e	0.91	0.91	0.91	0.91	1.61	1.61	0.91	0.91
	q_s	-0.52	-0.52	-0.52	0.00	0.00	0.00	-0.52	-0.52
	$q_e\, k_e/y$	-0.08	-0.23	-0.12	-0.29	0.47	0.45	-0.24	-0.21
	$q_s\, k_s/y$	0.51	0.64	0.79	0.08	0.16	0.13	0.73	0.69
	h	1.53	1.02	-0.73	0.07	-0.15	-0.07	0.57	0.57
BGP	y	-	2.23	2.23	2.23	3.16	3.16	2.23	2.23
	$\frac{y_{2007}^{Model}}{y_{2007}^{Data}}$	1.00	1.02	0.73	0.73	1.02	1.84	0.97	1.65

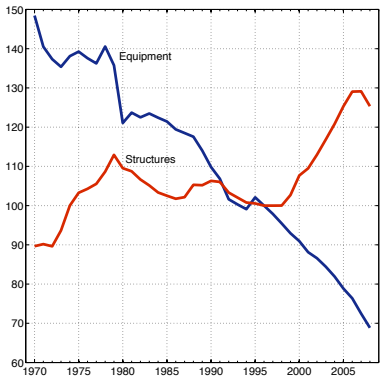
Notes: **BGP** refers to the growth rate at the balanced growth path.

Table 2: Average growth rate of output and its decomposition

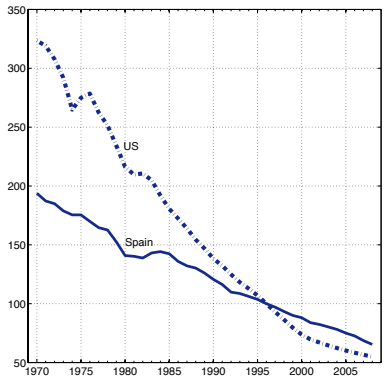
		Data	Benchmark	No Wedge	No Boom	US Price	LMR
1970-2007	A	0.94	0.98	1.17	1.87	2.05	0.98
	Z	1.00	1.00	1.00	1.00	1.00	1.00
	q_e	0.40	0.40	0.40	0.40	0.98	0.40
	q_s	-0.15	-0.15	-0.15	0.00	0.00	-0.15
	k comp.	-0.30	-0.27	-0.08	0.46	0.06	-0.27
1970-1985	A	1.47	1.50	1.76	2.92	2.57	1.51
	Z	1.72	1.72	1.72	1.72	1.72	1.72
	q_e	0.27	0.27	0.27	0.27	0.78	0.27
	q_s	-0.13	-0.13	-0.13	0.00	0.00	-0.13
	k comp.	-0.38	-0.35	-0.10	0.91	0.05	-0.35
1986-1995	A	0.88	1.08	1.31	1.78	1.62	1.08
	Z	0.60	0.60	0.60	0.60	0.60	0.60
	q_e	0.33	0.33	0.33	0.33	1.02	0.33
	q_s	0.02	0.02	0.02	0.00	0.00	0.02
	k comp.	-0.08	0.12	0.35	0.83	-0.01	0.12
1996-2007	A	0.01	-0.10	0.01	0.43	1.18	-0.12
	Z	0.10	0.10	0.10	0.10	0.10	0.10
	q_e	0.57	0.57	0.57	0.57	1.01	0.57
	q_s	-0.33	-0.33	-0.33	0.00	0.00	-0.33
	k comp.	-0.33	-0.44	-0.33	-0.25	0.06	-0.46
BGP	A	-	1.40	1.40	1.40	1.98	1.40

Notes: **BGP** refers to the growth rate at the balanced growth path.

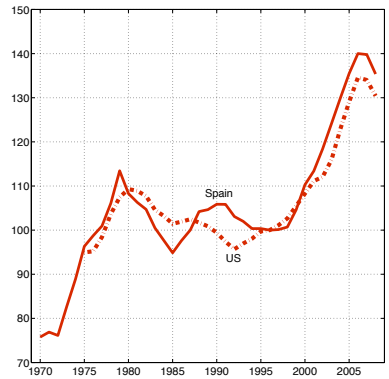
Table 3: Average growth rate of measured TFP and its decomposition



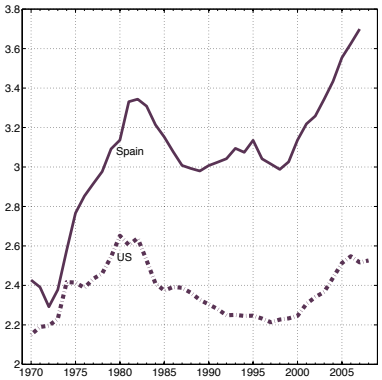
(a) Relative prices of capital goods



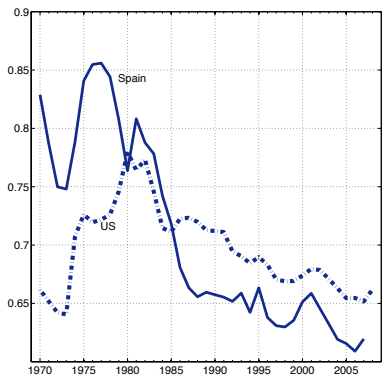
(b) Relative price of business equipment



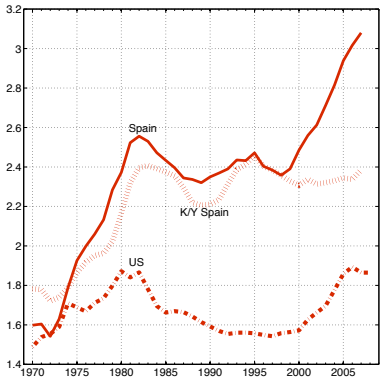
(c) Relative price of residential structures



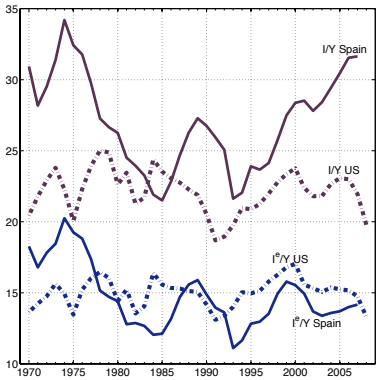
(d) $q\,K/Y$, total



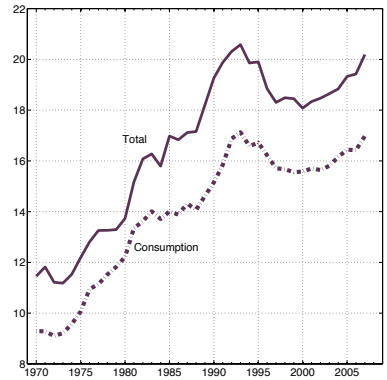
(e) $q\,K/Y$, equipment



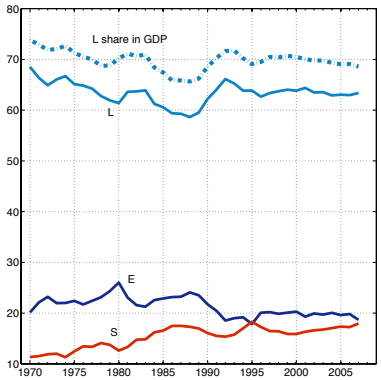
(f) $q\,K/Y$, structures



(g) Investment as % of output

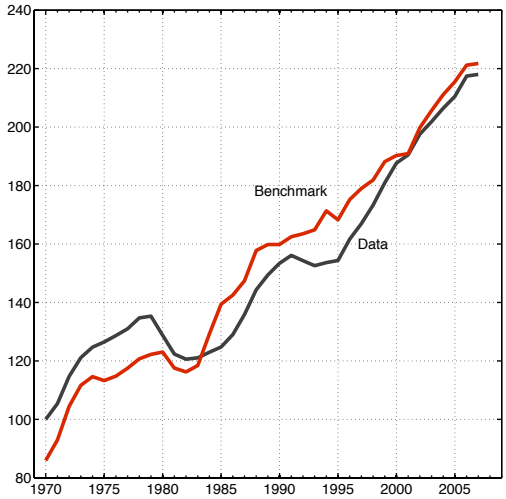


(h) Government expenditures as % of output

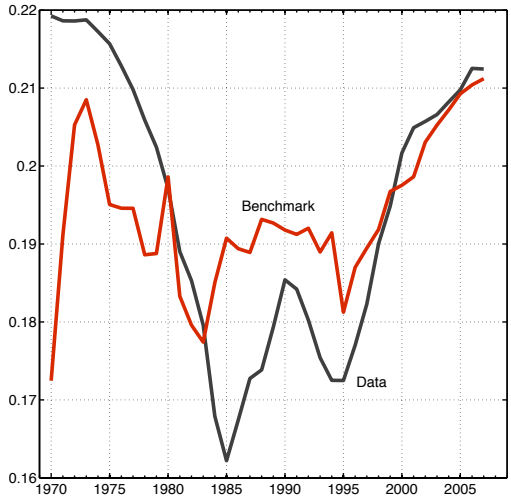


(i) Factor shares

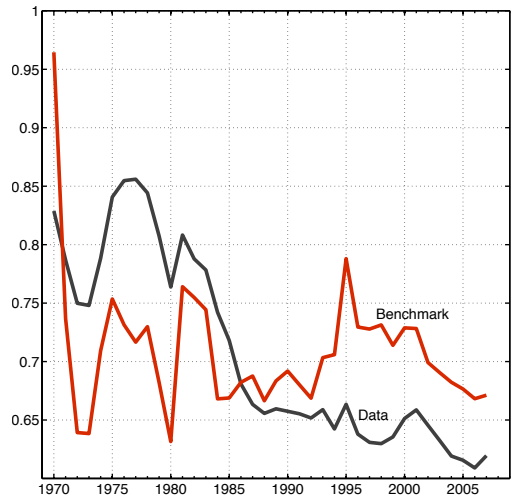
Figure 1: Spain 1970-2008



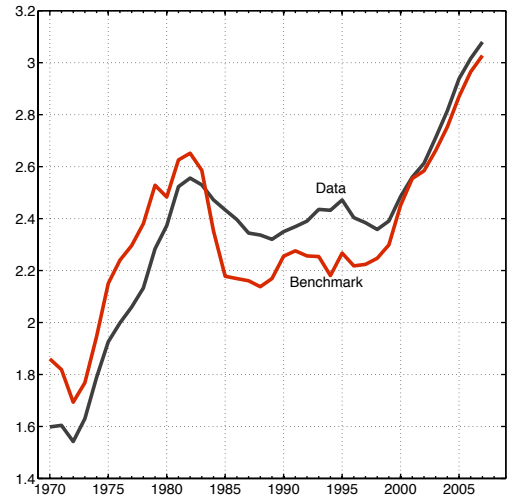
(a) Output



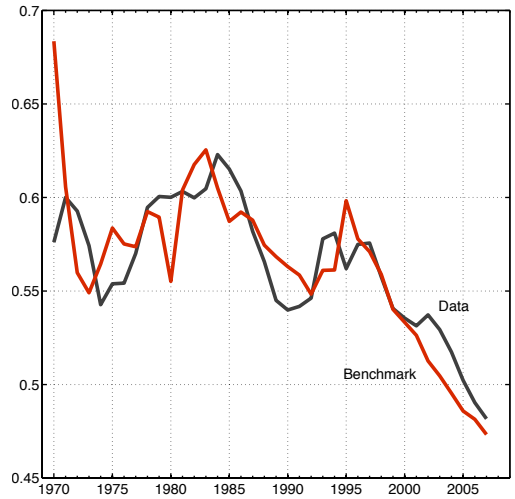
(b) Hours worked



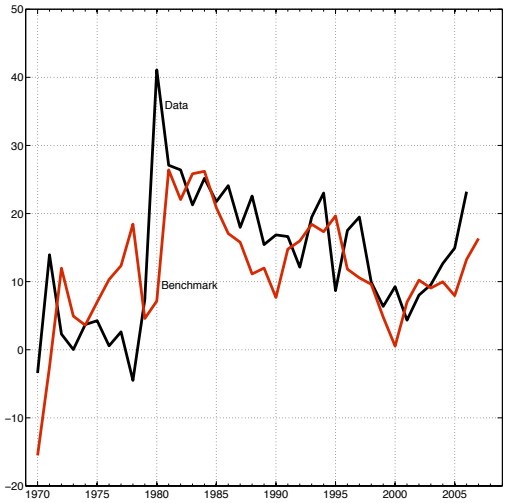
(c) $q\,K/Y$, equipment



(d) $q\,K/Y$, structures

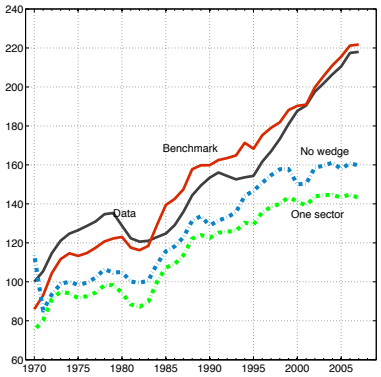


(e) C/Y

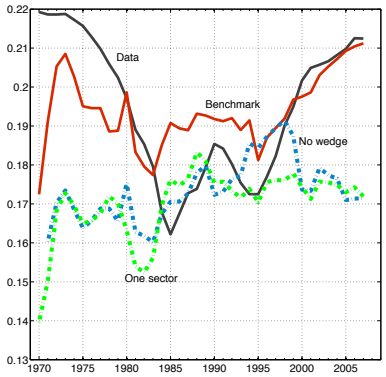


(f) Subsidy to structures as % of output

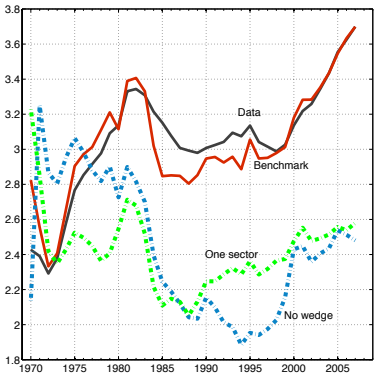
Figure 2: The benchmark economy



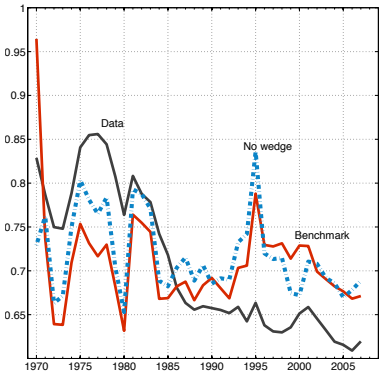
(a) Output



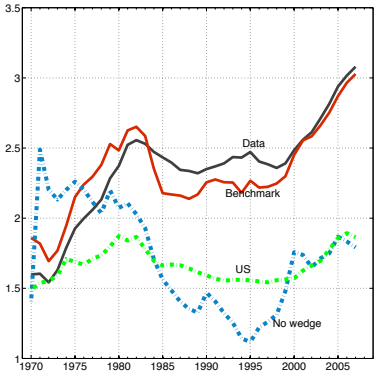
(b) Hours worked



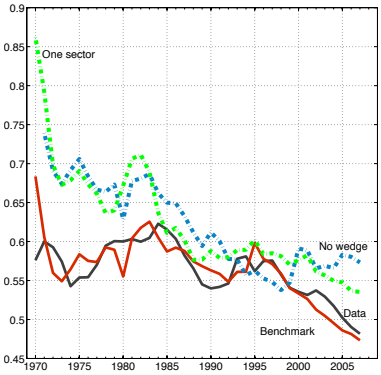
(c) $q\,K/Y$, total



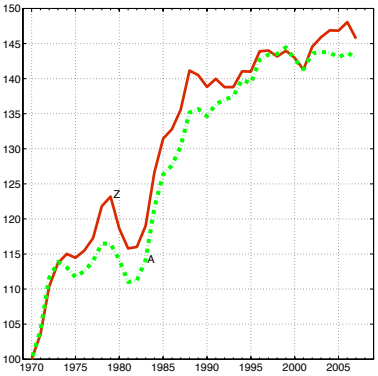
(d) $q\,K/Y$, equipment



(e) $q\,K/Y$, structures

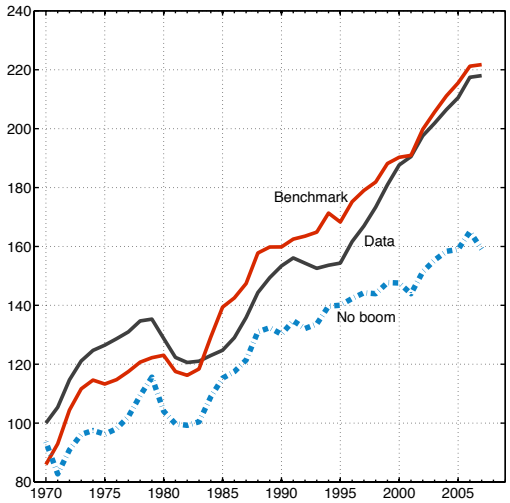


(f) C/Y

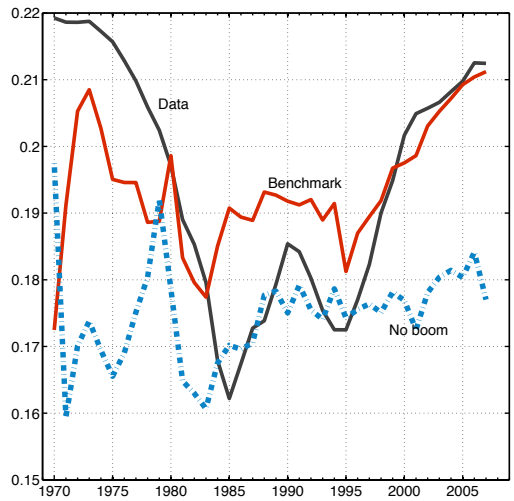


(g) Neutral technical change, Z, and TFP, A

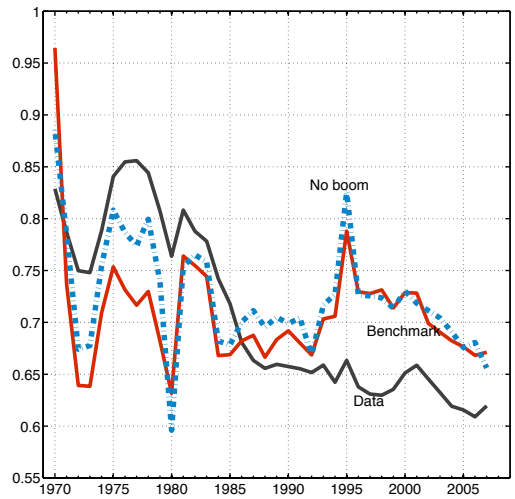
Figure 3: The effect of the subsidy. The three sector economy with no subsidy is called 'no wedge' (in light blue). The one sector economy in light green.



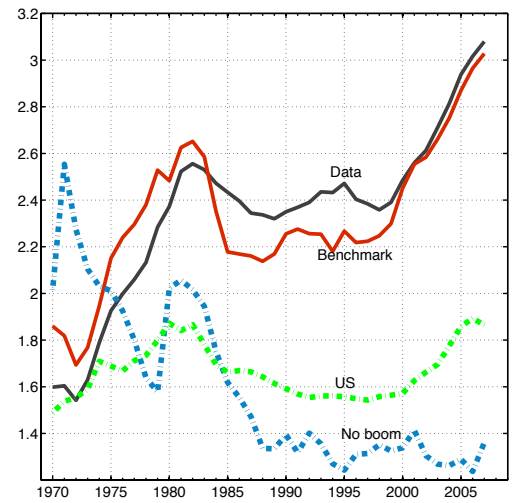
(a) Output



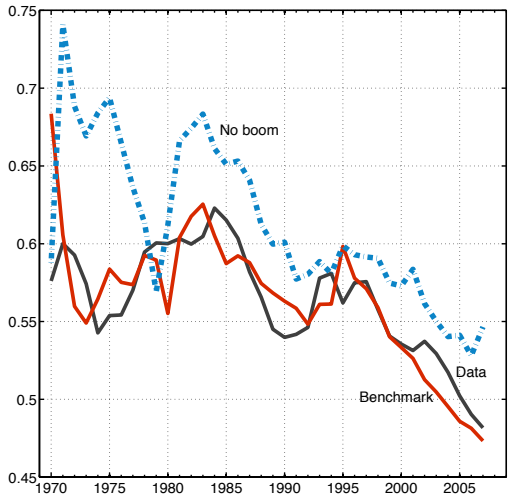
(b) Hours worked



(c) $q\,K/Y$, equipment

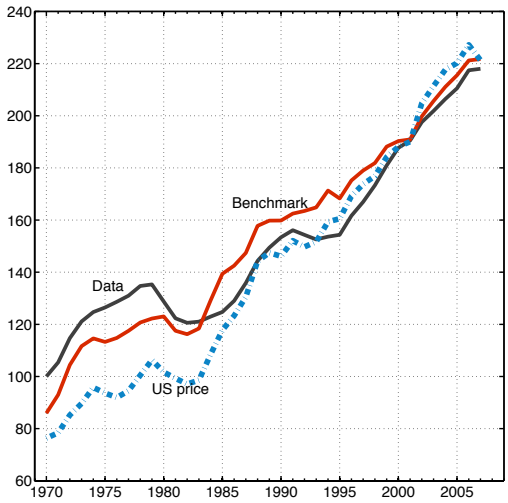


(d) $q\,K/Y$, structures

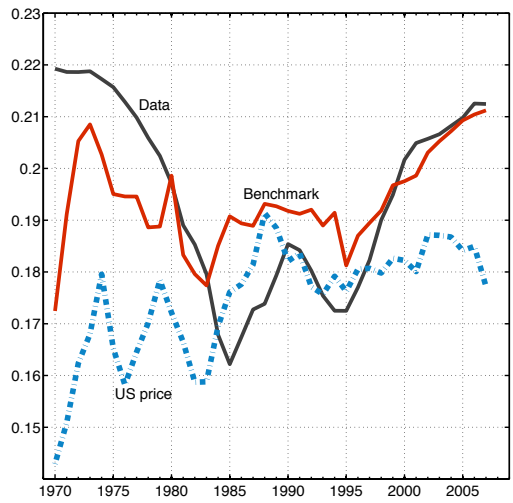


(e) C/Y

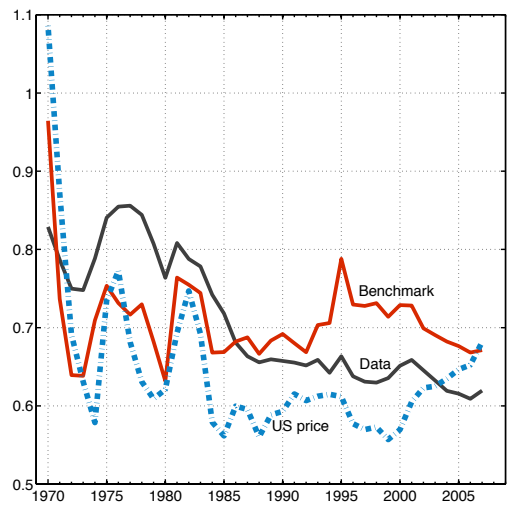
Figure 4: The effect of wedge and the housing price boom



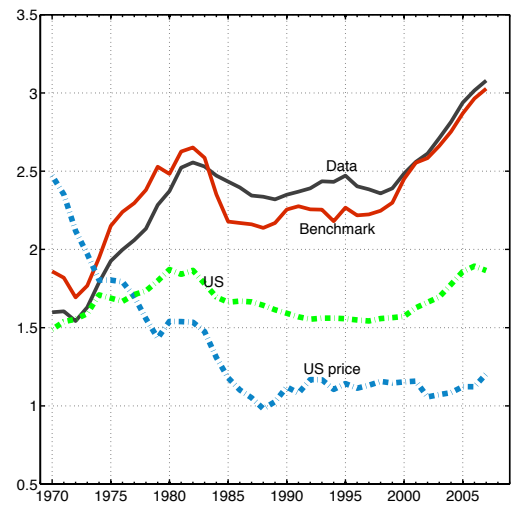
(a) Output



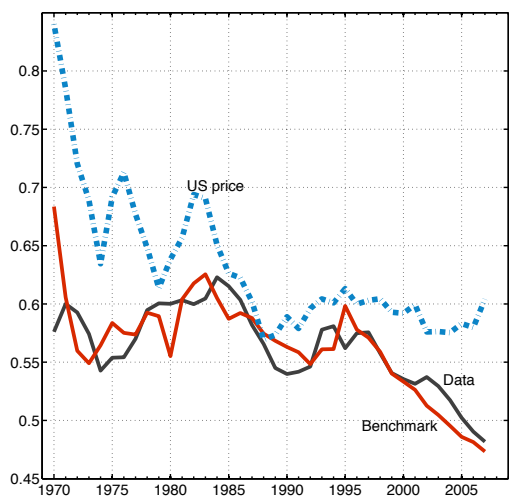
(b) Hours worked



(c) $q\,K/Y$, equipment

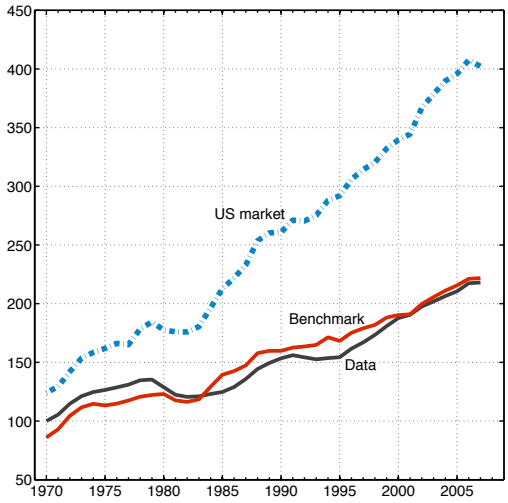


(d) $q\,K/Y$, structures

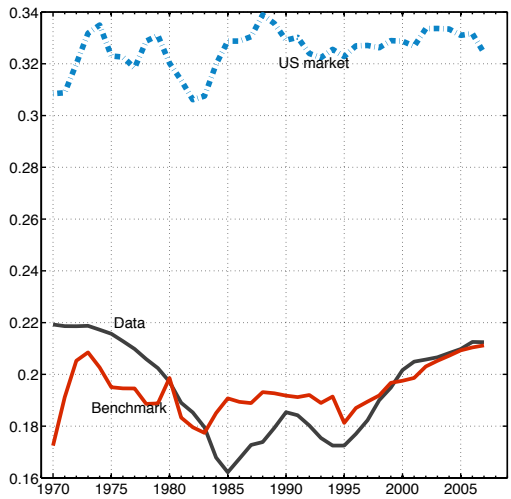


(e) C/Y

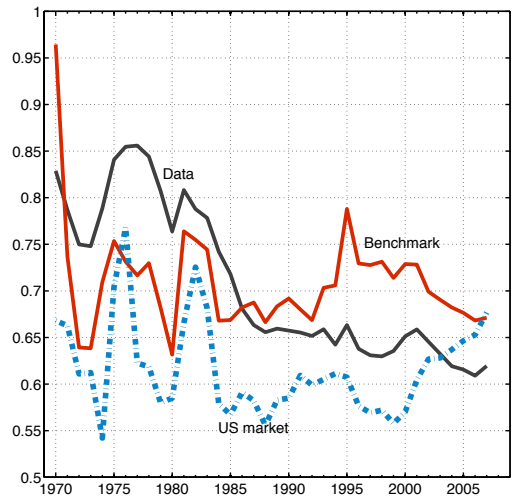
Figure 5: The effect of wedge and the housing price boom and low ISTC in equipment



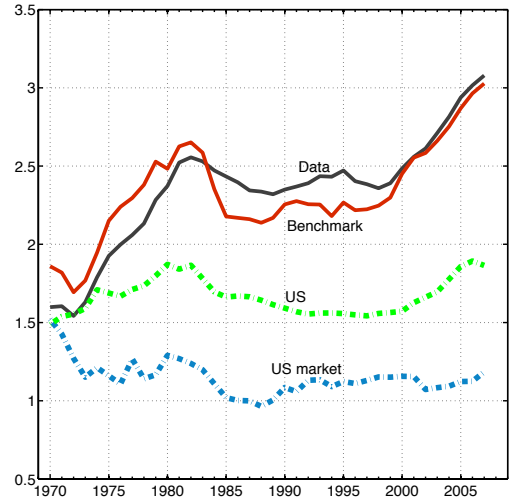
(a) Output



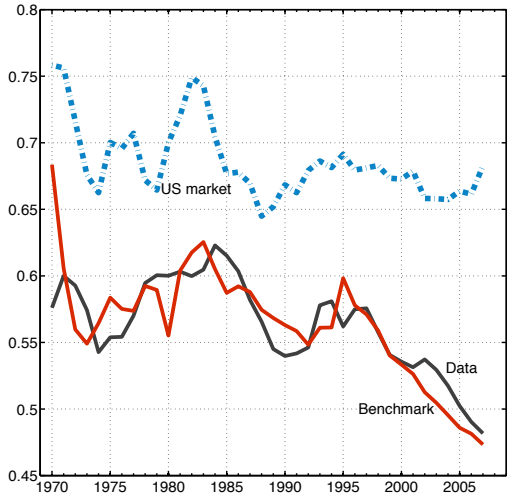
(b) Hours worked



(c) $q\,K/Y$, equipment

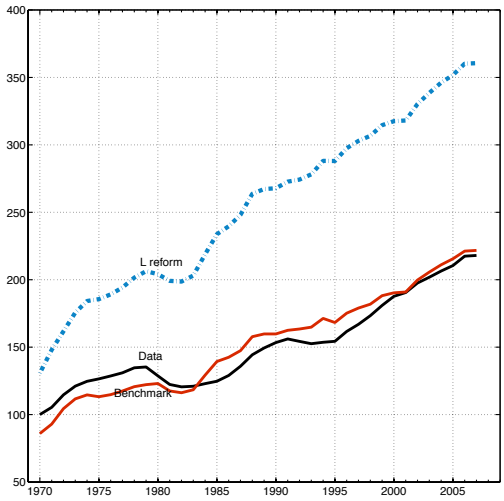


(d) $q\,K/Y$, structures

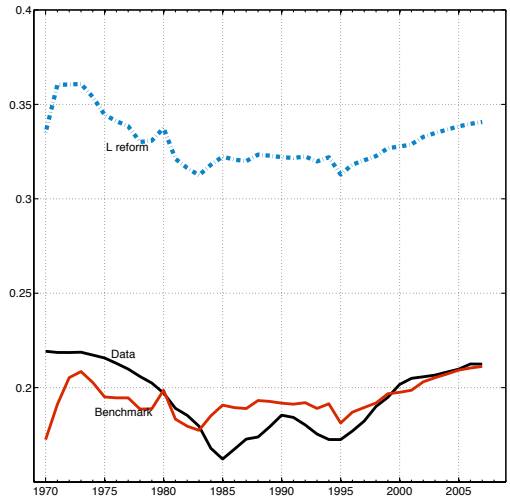


(e) C/Y

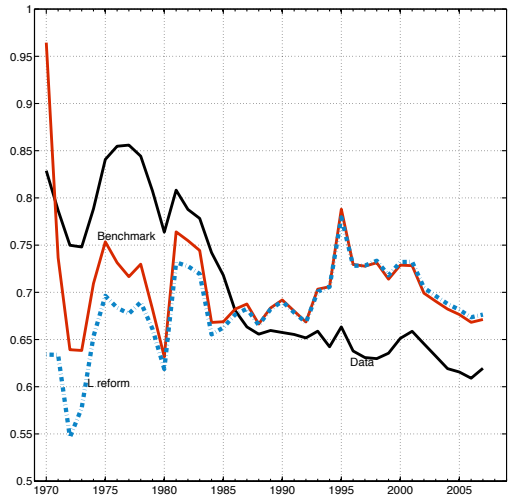
Figure 6: The effect of wedge, the housing price boom, low ISTC in equipment and labor market frictions



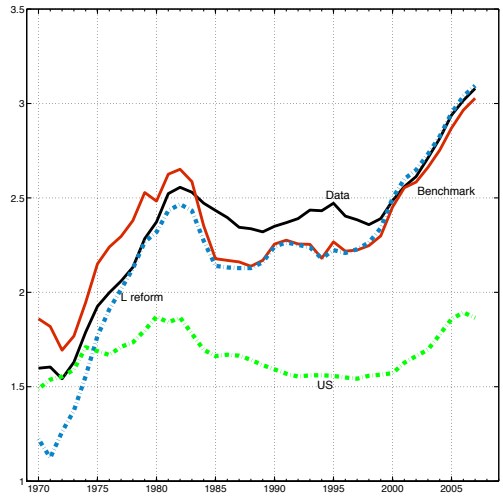
(a) Output



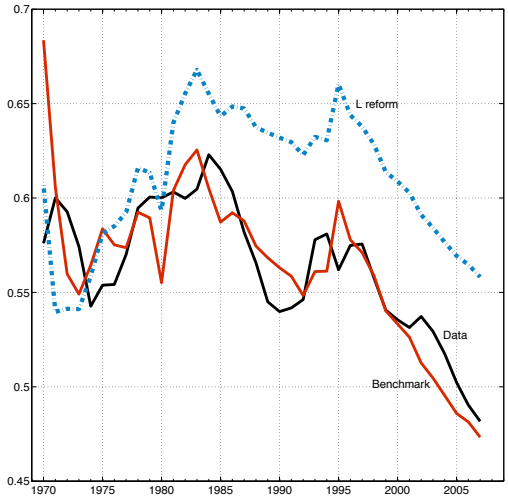
(b) Hours worked



(c) $q\,K/Y$, equipment

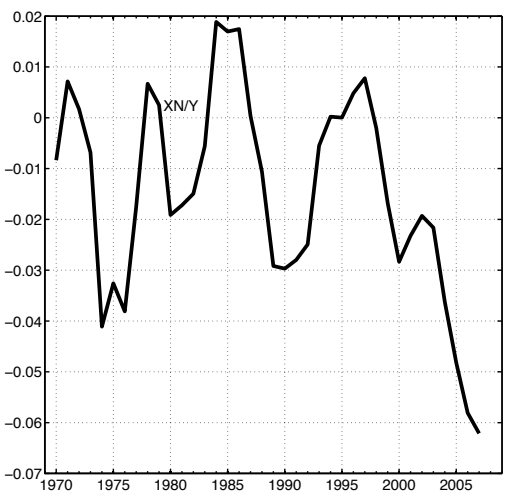


(d) $q\,K/Y$, structures

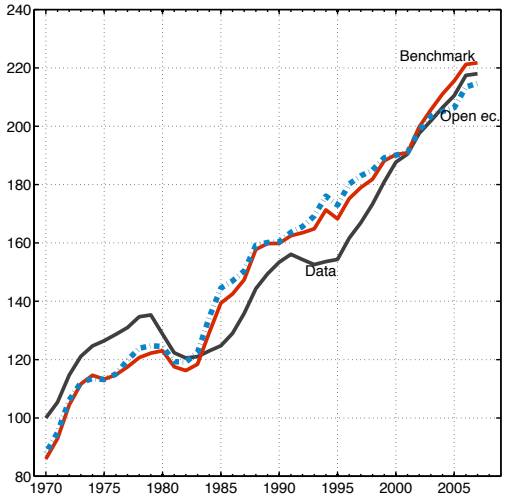


(e) C/Y

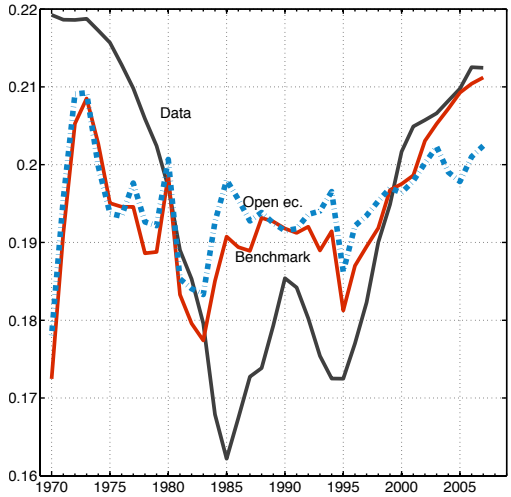
Figure 7: The effect of a labor market reform



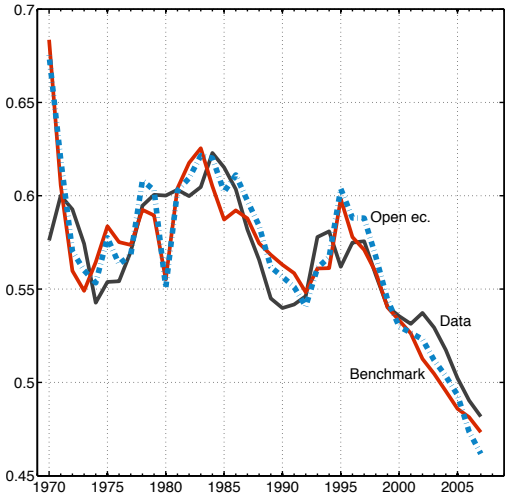
(a) XN/Y, Spain 1970-2007



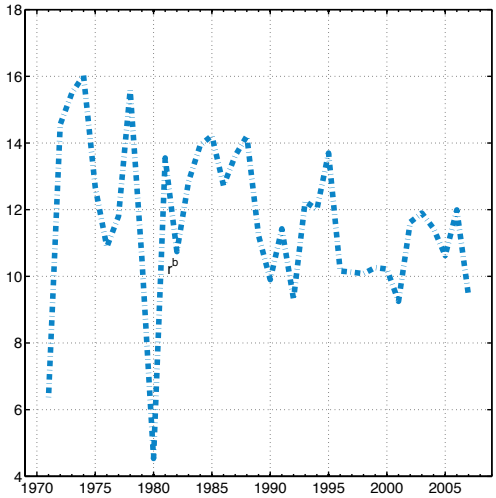
(b) Output



(c) Hours worked

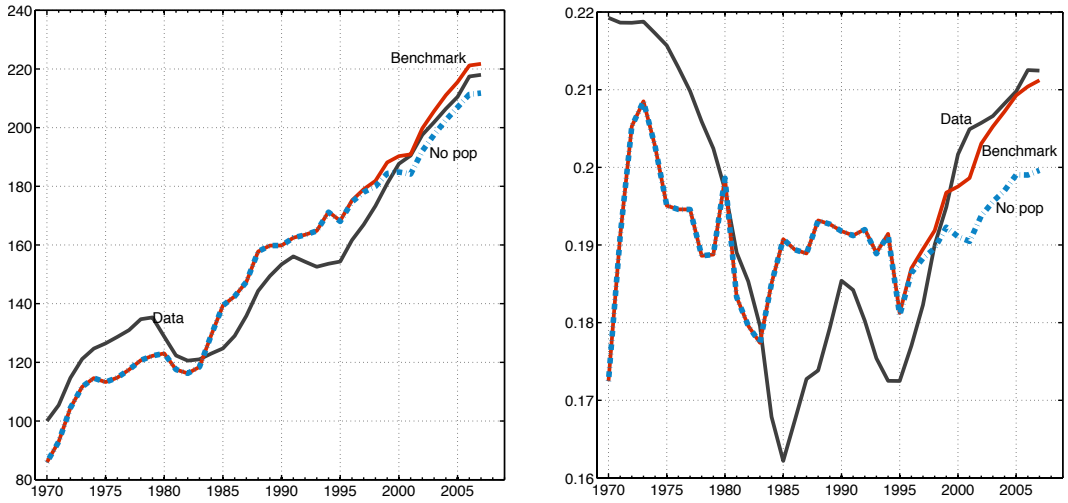


(d) $C/Y+$ trade balance



(e) The interest rate of the international bond

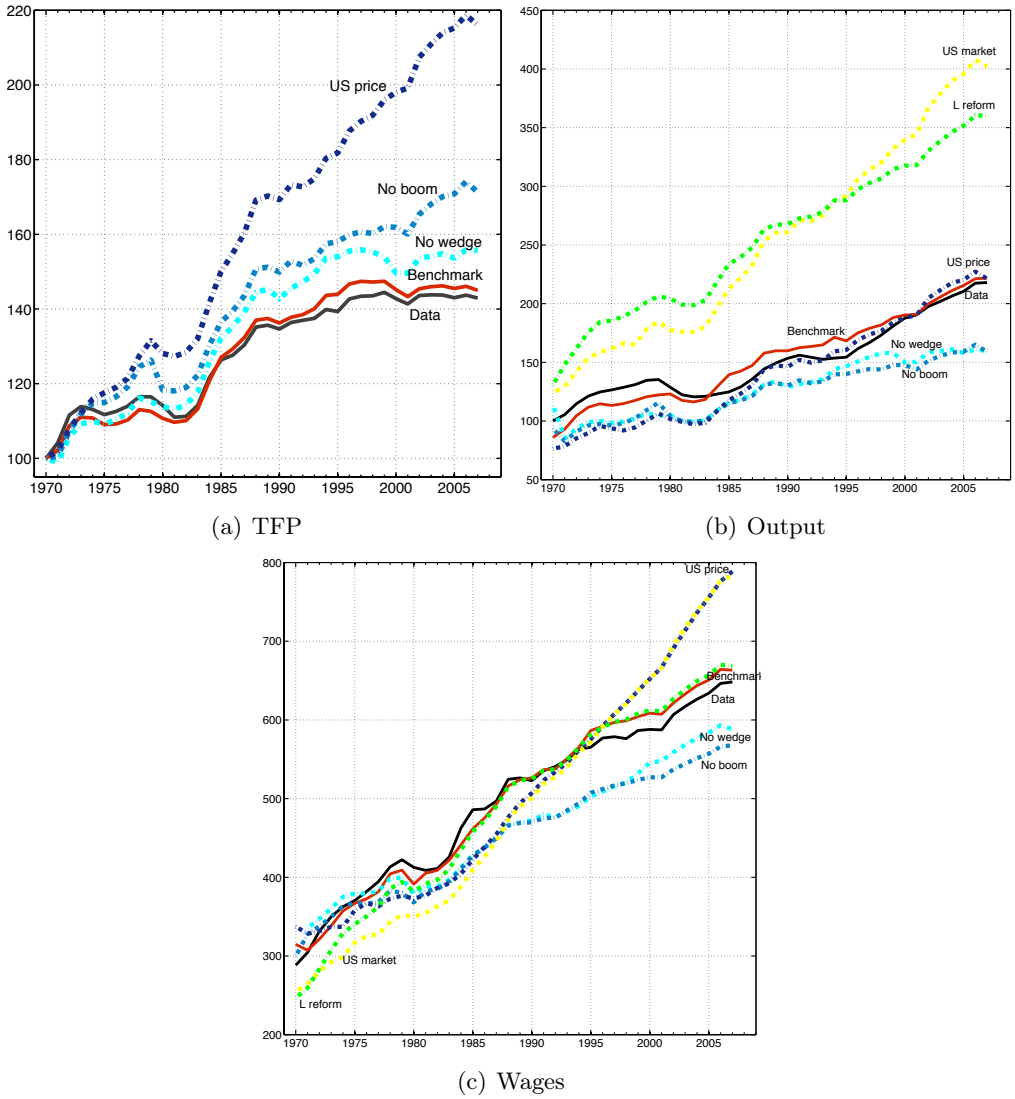
Figure 8: The open economy



(a) Output

(b) Hours worked

Figure 9: The effect of population growth



(a) TFP

(b) Output

(c) Wages

Figure 10: Comparing models

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