Structural Transformation, the Push-Pull Hypothesis and the Labour Market

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Abstract

This paper proposes a small-scale general equilibrium model of structural transformation with a non-agricultural labour market characterized by search frictions. The model is used to investigate the role of sectoral TFPs as main drivers of structural change and a new growth accounting exercise gives a quantitative reassessment of the importance of the labour reallocation bonus in structural transformations in the presence of labour market frictions. The model is calibrated to data for post-war Spain and its transition from dictatorship to democracy. Counterfactual simulations point towards productivity improvements in agriculture as the main driver, while modifications in labour market institutions affect mainly the labour market itself, with only a modest effect on structural change.

JEL codes: J40, O10, O11, O41, O47.

Keywords: dual economies, structural transformation, non-agricultural unemployment, matching frictions, growth accounting, Solow residual.

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1. Introduction

Structural transformation, and especially the process resulting from the movement of workers out of agriculture into other sectors, has always been recognized as a distinctive feature of development. It characterized early industrialized countries, like the UK, during the eighteenth and the nineteenth century, but also later starters like the US, or countries in continental Europe in the second half of the nineteenth century. More recently, Mediterranean European countries have experienced it since the end of the Second World War, while it still makes headlines for developing countries like Brazil, China and India.

A long tradition of studies by different authors has concentrated in either documenting the phenomenon or providing possible explanations of its underlying mechanisms.[1] In particular, much of the debate has focused on which sector's technological progress plays the main role in leading the process.

The study presented here aims to contribute to this debate by presenting a dynamic dual economy model of structural transformation with a fully specified labour market structure in the non-agricultural sector, which is described using a dynamic version of the search and matching model. In this way, the model introduces a framework for studying structural change in the presence of matching frictions. This is an important feature to be implemented in this type of model, as structural transformation is influenced by how rapidly workers are absorbed in the non-agricultural sector, which in turn is influenced by matching frictions.

After using the model to investigate the role of sectoral TFP growth in structural transformation, a second contribution of the paper is to study the transitional effects of changing labour market institutions. Finally, a new growth accounting exercise is proposed, which quantifies the role of labour reallocation in aggregate growth in the presence of unemployment and matching frictions.

The model is calibrated to post-war Spain with the main (but not sole) objective of highlighting the relative importance of within-sector productivity growth in overall structural change. By inducing transition with an exogenous path of sectoral TFPs, I will show how Spain's structural transformation was influenced by the combination of growing TFP in both sectors. Hence, the story here combines what in the literature has come to be known as agricultural 'push' with non-agricultural 'pull' and could therefore be consistent with the findings in Alvarez-Cuadrado and Poschke (2011) about these two forces.

However, differently from Alvarez-Cuadrado and Poschke (2011), who provide empirical evidence based on a model which links the evolution of within-sector productivities to the time path of the relative price, the analysis proposed here is based on some counterfactual experiments in which I "switch off" in turn technical progress in agriculture and in non-agriculture. I conclude that what really matters most is the "push" effect of rising agricultural TFP and hence a declining relative price of the

[1] As usually noted in the literature, early documenting efforts trace back to the works of Kuznets (1966) and Chenery and Syrquin (1975), while possible theories include those presented in Clark (1940) and Rostow (1960). The most recent developments in research on structural transformation are reviewed in Herrendorf et al. (2014).

agricultural good. Furthermore, since in the model capital is introduced as a factor of production in the non-agricultural sector, counterfactual experiments will also show that most of the "pull" effect on structural transformation has to be traced back to capital accumulation rather than pure technical progress in non-agriculture.

In the model agents are fully forward-looking, in that they are able to accurately forecast their future income streams and therefore able to make a dynamically-optimal migration decision. This is not needed when the labour market clears instantaneously and workers could costlessly reallocate at each point in time. But when the labour market is characterized by the presence of search frictions (or in general by involuntary unemployment), a proper modelling of a forward-looking migration decision is needed, and this is an additional contribution of this paper, which overcomes the ad-hoc assumptions, such as fixed wage differentials, of much of the existing literature on structural transformation.

Since the model is calibrated with Spanish data, it is necessary to take into account the particular historical experience this country faced in the reference period (1950-2005). The first decades after the war were characterized by a completely different institutional and political framework, in which Spain was still subject to the dictatorship of General Francisco Franco (which began in 1939), but had started its transition towards a market-oriented society (with the 1953 trade and military alliance with the US). This historical situation will be captured by a number of distinguishing features in the description of the non-agricultural labour market, allowing (and this is a second objective of the paper) the study of the effects of institutional changes on structural transformation. Therefore, another set of counterfactual experiments involves the study of the effect of an increase over time in worker bargaining power, while a third one analyzes the consequences of a transition to a free market economy, as captured by a reduction in the flow cost of opening a vacancy as a proxy for more general costs of entry.

Overall, the results from the baseline simulation suggest that the model is able to replicate the process of Spanish structural transformation, which in turn is found to be partially responsible for the increase in Spanish unemployment registered from the 1970s. Furthermore, counterfactual experiments show that the change in labour market institutions did not affect the process of structural transformation, which still seems to be driven by changes in sectoral productivities, in particular in agriculture. However, they obviously affected the non-agricultural labour market, influencing its ability to absorb the release of labour from agriculture, and therefore the level of unemployment.

The paper proceeds as follows: the next section relates the analysis to the closest research in the field, also describing the most relevant historical facts for postwar Spain. The theoretical model is outlined in section 3, while section 4 describes the growth accounting results. Section 5 discusses the calibration strategy undertaken and simulates the model, analyzing also results obtained from some counterfactual experiments, aimed at disentangling the relative contributions of sectoral TFP growth and labour market institutions to structural transformation. An application of the growth accounting exercise to the simulated data in the baseline case is given in section 6. Finally, section 7 makes some concluding remarks and outlines possible avenues for further research.

2. Related literature

The present paper features a dual-sector model with involuntary unemployment in the non-agricultural sector, arising from search frictions. In spirit and structure, the model is similar to that developed in Satchi and Temple (2009), but with some peculiarities and, most importantly, a different focus. If both contributions present models of structural transformation with search and matching in the labour market, Satchi and Temple (2009) apply it to the study of the emergence of a large informal sector in the Mexican economy and of the impact of payroll and corporate income taxes as well as different types of growth, considering variable search intensity in the labour market. However, their approach to the analysis is static. Here instead, the main research questions relate to the determinants of structural transformation, namely whether what matters most is productivity improvements in agriculture or in non-agriculture, and the effect of labour market institutions changing over time. Furthermore, this paper tackles the dynamic implications of such a model, including the introduction of forward-looking migration with transitional dynamics.

Looking in more detail to the literature on the determinants of structural transformation, a first view, starting with the work of Lewis (1954), identified the main source of structural transformation in the attracting force exerted by productivity gains in the non-agricultural sector. The Lewis version of the "pull" hypothesis (as it is sometimes called) relies, in fact, on the existence of a reservoir of surplus labour in agriculture which makes the labour input available at a fixed wage for firms in the manufacturing sector. Migration from agriculture is induced by investment in non-agriculture, and increases the overall size of manufacturing.[2] The model presented here relates to this literature in that it is able to accommodate "pull" effects as a consequence of efficiency improvements in the non-agricultural sector. In this sense, this paper is also related to the recent literature on technology-driven structural change, where technological differences across sectors play the dominant role, through sectoral heterogeneity in TFP growth (Ngai and Pissarides, 2007), capital intensity (Acemoğlu and Guerrieri, 2008) or elasticities of substitution between factors of production (capital and labour in Alvarez-Cuadrado et al., 2015, skilled and unskilled labour in Wingender, 2015).

This work is also located in the tradition of models spurred by the seminal contribution of Harris and Todaro (1970), where the process of rural-urban migration was analyzed highlighting its implications for the labour market. They explained the evidence of persistent migration in the presence of unemployment in the urban sector, which instead would naively be considered as a detriment to reallocation. In this sense, structural transformation can account for at least part of the increase in unemployment in urban

[2]Of course this is not the only way in which pull effects have been embedded in theories of structural transformation: Hansen and Prescott (2002) and Ngai (2004) study models capable of delivering structural transformation as the development process from a Malthus type economy to a Solow type (the first) and discuss the implications of barriers to capital or technology accumulation (the second).

areas. A large literature still active today has been stimulated by their contribution, providing different explanations to overcome their initial assumption of an exogenous wage differential.[3]

An alternative view to the "pull" hypothesis has focused on the central importance of agricultural productivity improvements as the driving force of structural change. This research, reviewed extensively in Gollin (2010), combines the evidence of efficiency gains in agriculture with implications coming from Engel's law: as the income elasticity of demand is lower for goods produced within the agricultural sector than outside, it is possible to satisfy the needs of the overall economy while employing fewer workers, releasing labour towards other sectors (hence its labeling as "push"), since the reduction in the factor input is replaced by growth in efficiency. The adoption of non-homothetic specifications of preferences is required to accommodate Engel's law effects. Examples of this stream of research, tracing back to what Schultz (1953) defined as the "food problem", include classic references such as Matsuyama (1992), Laitner (2000), Caselli and Coleman (2001), Gollin et al. (2002, 2007) and more recently Gollin and Rogerson (2010).

A standard feature in models of structural change is assuming a closed economy to international trade. However, the autarky assumption is not innocuous. As Matsuyama (1992) pointed out, implications for structural transformation radically change when assuming a small open economy with prices set exogenously. In this case, if the country under study has a vantage in agriculture, it could remain locked into this sector, failing to industrialize and develop further.[4] In the present paper however, the closed economy assumption fits especially well with the historical experience under consideration. As a matter of fact, Spain was close to autarky from the end of WWII to the early 1950s, both as a conscious policy choice of General Francisco Franco and because the country was subject to a UN boycott. Only at the end of the 1950s, in the face of a balance-of-payments crisis that was leading the country to bankruptcy, did Franco reluctantly allow for a gradual opening to international trade. However, the evidence suggests that Spain reached levels of openness comparable with those of the main European countries only in the late 1980s, when it joined the European Economic Community.[5]

With respect to the non-homotheticity assumption, Ngai and Pissarides (2007) constitute a notable exception in that they present a multisector model in which differences in TFP growth rates alone yield structural change, provided that the elasticity of substitution across final goods is lower than unity. However, as noted by Ngai and Pissarides (2007) themselves, these two explanations are not alternatives, as they could coexist within the same model: see for instance Rogerson (2008) and Boppart (2014). The model presented here relates to this stream of literature in that it features both nonhomothetic preferences and different sectoral TFP growth rates across sectors.

[3]A good part of this literature is described in the review of dual economy models in Temple (2005).

[4]Laitner (2000) shows that the assumption on openness could also have effects on other dimensions: for example international trade could help to explain the evidence of higher average saving rates in less developed countries.

[5]To give a sense of dimensions, according to the Penn World Table 7.0, the average Spanish trade share during the 1950s was only 45% of the Italian one, 35% of the French and 21% of the British. The corresponding average figures for the 80s became 89%, 83% and 71%.

More recently, Alvarez-Cuadrado and Poschke (2011) proposed a new attempt to investigate opposing views about the relative importance of "push" and "pull" effects. Based on cross-country evidence - for eleven developed countries between 1800 and 2005 - on the behaviour of the relative price across the two sectors, they conclude in favour of a "sequence" argument: "pull" is what mattered at first, followed by "push" effects. In their framework, increases in the relative price of the agricultural good over time are a sign of faster technological progress in non-agriculture, while the opposite case is interpreted as evidence of faster growth in agriculture. In particular, "pull" is found to be the main driver of structural change before 1960, while later the evidence, although less robust, is in favour of "push". This paper's analysis is broadly consistent with the evidence provided by Alvarez-Cuadrado and Poschke (2011), as the model delivers a hump-shaped path for the relative price: increasing in the first two decades, and then decreasing. However, counterfactual simulations will lead us to attribute more importance to productivity improvements in agriculture rather than in the non-agricultural sector.

A final aspect of the analysis is concentrated in quantifying the role of labour reallocation in aggregate growth by means of growth accounting techniques. Following the foundations given in Solow (1957), a number of studies have applied this technique to reduce the "measure of our ignorance" (Abramovitz, 1956), deriving more detailed decompositions of TFP growth depending on which underlying model is assumed.[6] In the context of structural transformation, what matters is the growth bonus given by the reallocation of workers across sectors. Temple (2001) is the closest reference to the approach adopted here, where TFP growth is decomposed as the sum of sectoral productivity growth and a labour reallocation term. The decomposition proposed here can be thought of as an extension to the case of endogenous unemployment, arising from the assumption of matching frictions in the urban labour market, which absorb part of the growth bonus from structural change. Moreover, a further extension is proposed in the appendix, where the decomposition takes into account the possibility of increasing returns to scale in the non-agricultural sector, and time variation in efficiency units of labour.[7]

2.1. Historical background

Since the model is calibrated with Spanish data, it is necessary to take into account the particular historical experience this country faced in the reference period.[8]

[6] Much of the literature is reviewed in Barro (1999) and Barro and Sala-i-Martin (2004).

[7] In relation to the efficiency units measurement, recently Vollrath (2013) proposed an additional correction based on the actual labour effort exerted within each sector, with the correction factor being related to information on work time allocation decisions. A similar adjustment was proposed also in Gollin et al. (2014).

[8] The Spanish economic experience both under Franco and, after his death, during the transition to full democracy has been widely analyzed in the literature, in particular in works by Leandro Prados de la Escosura. The purpose of the following discussion is twofold: on the one hand, it highlights key aspects of the transition to democracy which mostly affected the labour market; on the other hand, it explains how the transition was translated in (exogenously) time-varying parameters of the model of the following section. The historical account draws extensively on Prados de la Escosura and Sanz (1996), Prados de la Escosura et al. (2011) and Eichengreen (2007), while more details on the labour market evolution are provided in Bentolila and Blanchard (1990), Bentolila and Jimeno (2006) and, for the most recent developments, Bentolila et al. (2010).

In 1939, at the end of the civil war, General Francisco Franco took power in Spain and retained it until 1975, the year of his death. During the first part of his dictatorship he pursued nationalistic autarkic policies, characterized by controlled prices in agriculture, low levels of foreign trade, and rigid authorization from the Ministry of Industry required for any industrial investment. Overall, up to the beginning of the 1950s, the country was virtually an autarky, almost completely isolated from relations with the rest of the world (because of Franco's support for the Axis forces during the war), with rigid state control of the most strategic industries, and featuring huge barriers to entry for any private industrial investment.

This condition of substantial isolation continued up to 1953, when the beginning of the Cold War and Franco's strong anti-communism helped in opening up Spanish international relations, in particular with the United States (the *Pact of Madrid*). Although Spain had not been included in the Marshall Plan, American assistance started to flow into the country, in particular in exchange for the establishment of four military bases. More importantly, the 1951 change of government signalled also a gradual change in the anti-market attitude of the dictatorship, which started to remove food rationing and quotas on energy and raw materials (Prados de la Escosura et al., 2011).

Finally, the point of no return was reached in 1959 when Franco, on the brink of a balance of payments crisis, announced the *Stabilization and Liberalization Plan* which marked a change of direction towards free market policies.[9]

The gradual transition from a rigid state-controlled economy to the more liberalized approach of the 1960s had effects on the labour market not only through entry decisions, but also through labour relations between firms and workers. The system of industrial relations under Franco was firmly organized, with compulsory membership in a single national union of workers and employers, which not surprisingly had little effect on bargaining over labour conditions, since strikes and layoffs were substantially outlawed, and the government had the final say in setting wages (Prados de la Escosura and Sanz, 1996; Bentolila and Jimeno, 2006). The end of the dictatorship allowed legalization of unions and standard collective bargaining was established. However, the period of political unrest that followed, and the related competition for worker representation (and therefore for power) between socialist and communist unions led to huge increases in wages, with firms having little ability to counteract them in any way (Bentolila and Blanchard, 1990). Furthermore, production costs were already increasing as a result of the contemporaneous oil shocks, whose effects were therefore amplified. Thus between the end of 1970s and the early 1980s major steps had to be undertaken in order to moderate wage increases.[10]

Since then, apart from the content of the single agreements signed over the years, which were obviously responding to current macroeconomic circumstances, the general regulation of the collective

[9] Spain joined the IMF, World Bank and GATT respectively in 1958, 1959 and 1963.

[10] In 1977 the "Moncloa agreements" were signed, which established on the one hand that expected future and not past inflation had to be taken into account in the wage bargaining process, and on the other a restrictive monetary policy (Bentolila and Blanchard, 1990).

bargaining system did not change much (Bentolila and Jimeno, 2006): collective bargaining takes place at the provincial-industrial level, with resulting conditions being legally binding as a lower bound for all workers. Affiliation to unions is low, since it is not needed by unions to participate in collective bargains. It is sufficient, instead, to have reached at least 10% of votes at the national level (or 15% at the regional level) in workers' representatives elections and workers can vote even in absence of direct affiliation (Bover et al., 2002). In addition, unemployment benefits were introduced in 1961, but took their modern form the year after Franco's death, in 1976. Since then a number of reforms have taken place first enlarging (1984, 1989) and then reducing (1992) entitlements and amounts of benefits.[11]

This particular evolution of industrial relations in Spain will be translated within the search and matching framework presented in the following section by assuming an exogenous change over time in the parameters capturing worker bargaining power (β), vacancy posting costs relative to the non-agricultural wage (ξ) and the replacement ratio (η). A detailed description of the assumptions underlying the calibration will be provided in section 5.1., but let us first introduce the model.

3. The model

The economy under consideration is a closed economy characterized by two sectors: agriculture (which will sometimes be called "traditional" and is indexed by a) and non-agriculture (which is indexed by m). The nominal output of the whole economy is given by the sum of output in both sectors:

$$Y = Y_m + p_a Y_a \tag{1}$$

where the relative price of the agricultural good in terms of the non-agricultural good is denoted by p_a.

Population, L, is formed by a continuum of households and the mass of workers living in the city is denoted by L_c. For simplicity, there is no population growth in steady-state, but in the calibration I will capture growth during transition in a way that will be discussed explicitly in section 5..

Agriculture produces an agricultural good, which can only be consumed, and its demand is denoted by c_a. The non-agricultural good can either be consumed (c_m), or invested (I_m). In agriculture, firms employ labour and land as factors of production, with total land endowment fixed and normalized to 1, and produce output Y_a, while in non-agriculture labour and capital (K_m) are used to produce output Y_m.

All income is shared within the household and is either consumed or invested in a fixed fraction, with s denoting the exogenous saving rate. Each member of the household can work in either sector, and is freely mobile across them.[12]

[11] For more details, see Bentolila and Jimeno (2006) and the references therein.

[12] The current model could be easily extended using efficiency units of labour, in order to consider time variations in the endowment of human capital and in the amount of average working hours. However, in the calibration with Spanish data the two effects offset each other almost perfectly leaving the total amount of efficiency units constant over time.

Finally, as for factor compensation, agriculture is perfectly competitive and provides a wage w_a, while non-agriculture is characterized by search frictions and provides a wage w_m. Capital and land owners are compensated with rates of return r and r_a respectively.

Following Irz and Roe (2005), to ensure that there are no-arbitrage opportunities in asset markets (land and capital), the following no arbitrage condition must hold at every point in time:

$$r - \delta = \frac{r_a}{p_l} + \frac{\dot{p}_l}{p_l} \tag{2}$$

where the left hand side denotes returns from investment of one unit of income in physical capital net of the cost of depreciation (δ), and the right hand side returns to investment in land capital, including capital gains from changes in the price of land p_l. Thus, returns will be equated by the path of the price of land.

3.1. Allocation of consumption

Consumers' preferences are described according to the following Stone-Geary utility function:

$$U(c_a, c_m) = B(c_a - \gamma_a)^{1-\lambda_p}(c_m + \gamma_m)^{\lambda_p} \tag{3}$$

where $B \equiv \lambda_p^{-\lambda_p}(1-\lambda_p)^{-(1-\lambda_p)}$ is a constant (useful for simplifications), λ_p coincides with the budget share of the non-agricultural good in the limit as total expenditure approaches infinity, γ_a denotes the subsistence level of consumption of the agricultural good, while γ_m captures an exogenous endowment of the non-agricultural good. The adoption of these type of preferences is useful for two main reasons: firstly, given the long-run perspective on structural transformation considered in this paper, non-homotheticity implies an income elasticity of food less than 1, ensuring consistency with Engel's law; secondly, following Alvarez-Cuadrado and Poschke (2011), it may be thought to capture, at least in reduced form, the role of home production through the term γ_m.

At every point in time consumers maximize their utility in order to derive the best allocation of consumption across the two goods subject to the following budget constraint on consumption expenditure:

$$p_a c_a + c_m = (1-s)(\Upsilon_m + p_a \Upsilon_a) \tag{4}$$

where Υ_m and $p_a\Upsilon_a$ are income levels derived from the respective sectors.[13] The assumption underlying (4) relates to the size of the household: a large household is assumed where each member chooses in which sector to seek employment and then shares its income within the household. Therefore, it

Thus, for simplicity here I report the model in its basic version, which is the version actually calibrated for Spain. We leave to the appendix the description of an extended version of the model with efficiency units of labour.

[13]Note that the assumption of a fully-competitive labour market in agriculture implies the coincidence of income and output (ie, $\Upsilon_a = Y_a$), while this equivalence is not satisfied in non-agriculture, where the assumption of search frictions requires value added to be measured as total non-agricultural output net of recruitment costs.

is assumed that the household saves a constant fraction of its income, regardless of the sources of income.

The demand functions implied by the optimization problem summarized by (3) and (4) can be derived as:

$$c_a = (1-\lambda_p)p_a^{-\lambda_p}\bar{c} + \gamma_a \tag{5}$$

$$c_m = \lambda_p p_a^{1-\lambda_p}\bar{c} - \gamma_m \tag{6}$$

where all variables have already been described previously apart from $\bar{c} = U(c_a, c_m)$ which denotes an index of real consumption.

Following the assumption of full consumption of the agricultural good and using (4), the market-clearing conditions for each sector's good will be:

$$p_a c_a = p_a Y_a \tag{7}$$

$$c_m = (1-s)\Upsilon_m - s p_a Y_a. \tag{8}$$

Finally, combining (5) and (6) with (7) and (8), yields the equation for the behaviour of the relative price:

$$\frac{\lambda_p}{1-\lambda_p} = \frac{(1-s)\Upsilon_m - s p_a Y_a + \gamma_m}{p_a(Y_a - \gamma_a)} \tag{9}$$

3.2. Agriculture

Since the labour income share in the Spanish agricultural sector varied significantly during the post-war period, firms in agriculture are assumed to combine labour and land according to the following CES production function:

$$Y_a = A_a[\alpha R^{-\rho} + (1-\alpha)L_a^{-\rho}]^{-1/\rho} \tag{10}$$

where α and ρ are parameters related to factor shares and the elasticity of substitution respectively, $R(=1)$ is land and L_a is employment in agriculture. Finally, A_a denotes agriculture productivity.

Although the model does not feature productivity growth in the steady state, in the calibration I will induce transitional dynamics by a process of adjustment of TFP in both sectors, imposing the same pattern as the one observed in the data.

Since this sector is fully competitive, all factors of production are paid their marginal products and there is no unemployment:

$$w_a = p_a(1-\alpha)A_a^{-\rho}\left(\frac{Y_a}{L_a}\right)^{1+\rho} \tag{11}$$

$$r_a = p_a \alpha A_a^{-\rho} Y_a^{1+\rho} \tag{12}$$

which implies equality between output and value added: $p_a Y_a = w_a L_a + r_a$.

3.3. Non-agriculture

The representative firm output in non-agriculture results from combinations of labour and capital:

$$Y_m = A_m K_m^{\mu}(L_m)^{1-\mu} \tag{13}$$

where firms level of output is denoted by Y_m, with capital K_m (with elasticity μ), and labour employed L_m, while A_m is the overall non-agriculture sector's TFP. In this case I choose a standard Cobb-Douglas form for the production function to keep the model simple, but it is also justified in the calibration exercise by the apparent constancy of the labour income share in the Spanish non-agricultural sector.

As for capital accumulation, gross investment ($I_m = \dot{K}_m + \delta K_m$) is the part of total income which is not spent on consumption, and therefore the households' budget constraint will take the form:

$$p_a c_a + c_m + \dot{K}_m + \delta K_m = \Upsilon_m + p_a \Upsilon_a \tag{14}$$

Using (4) and the income-output identity in agriculture ($\Upsilon_a = Y_a$), the capital accumulation equation will be:

$$\dot{K_m} = s(\Upsilon_m + p_a Y_a) - \delta K_m \tag{15}$$

where Υ_m is total value added in non-agriculture and will be defined in detail at the end of the next section.

3.3.1. Labour market in non-agriculture

Following Pissarides (2000), production in non-agriculture is described by a standard search and matching approach, with no on-the-job search or endogenous job destruction, but with a few twists to adapt it to a model of long-run growth. Vacancies and unemployed workers are matched according to the following matching function:

$$m = M_p v^{1-\gamma} u^{\gamma} \tag{16}$$

where M_p measures the efficiency of the matching technology, u and v are respectively the rates of unemployment and vacancies in the non-agricultural sector, and γ is the elasticity of matches with respect to unemployment. Denoting labour market tightness as $\theta \equiv v/u$, vacancies are filled at rate $m/v = q(\theta) = M_p\theta^{-\gamma}$ (vacancy duration$=1/q(\theta)$) and unemployed workers get jobs at rate $m/u = \theta q(\theta)$ (unemployment duration$=1/\theta q(\theta)$). Already existing jobs are destroyed at an exogenous rate λ.

Furthermore, firms have to pay a flow cost (c) for keeping a vacancy open, which is assumed to be increasing with the average non-agricultural wage ($c = \xi w_m$), since such costs typically involve paying some employees in order to perform related tasks such as advertising positions, screening applications and holding interviews.[14] On the other hand, when a match with a prospective worker is realized, the j-th firm hires capital k_{mj} in order to start production. Thus, the asset equations describing the value of a filled job (J) and unfilled vacancy (V) will be respectively:

$$r(J_j + k_{mj}) = (f(k_{mj}) - w_{mj} - \delta k_{mj}) + \lambda(V - J_j) + \dot{J}_j \tag{17}$$

$$rV = -c + q(\theta)(J - V) + \dot{V}. \tag{18}$$

Following again Pissarides (2000), when thinking about net profits the value of a filled job in (17) has to take into account the rental cost of capital as well as its depreciation rate. Since rented capital can be returned when the match breaks down, the value of an open vacancy does not need to take it into account.

Every firm will maximize the value of a job by renting capital until its marginal product equates total rental costs, so:

$$r + \delta = \mu \frac{Y_{mj}}{K_{mj}} \tag{19}$$

while the marginal product of labour is:

$$y_{mj} = (1 - \mu) \frac{Y_{mj}}{L_{mj}} \tag{20}$$

since a single firm is not large enough to influence the overall size of the sector.[15] Noting that (19) implies that all firms will choose the same amount of capital per units of labour k_m, and using the assumption of the production function with constant returns to scale at the firm level, the marginal product of labour will also be the same across firms and can be written as: $y_m = f(k_m) - (r + \delta)k_m$.

On the other hand, unemployed workers enjoy unemployment benefits (z), financed by lump-sum taxes, which are assumed to be increasing with the non-agricultural wage ($z = \eta w_m$), to keep pace with growth of earnings in the sector. The parameter η could therefore be interpreted as the replacement ratio. Assuming unemployment benefits proportional to wages, rather than keeping them fixed at some level, is the most natural assumption when looking at models with growth. This assumption implies that wages fully absorb productivity changes, a desirable feature of any model taking a long-run perspective.

[14] In the context of this model it may be more appropriate to think about the parameter ξ as entry costs faced by entrepreneurs when engaging in a production activity: it is indeed through this parameter that some of the Spanish evolution from autarky to a free market economy will be captured. Thus, when in the following sections ξ will be referred to as capturing recruiting costs, the latter should be interpreted in a broader sense.

[15] In other words the firms' production technology displays constant returns to scale.

The asset equations for workers will therefore look like:

$$\begin{aligned} rU &= z + \theta q(\theta)(W - U) + \dot{U} && (21) \\ rW &= w_m - \lambda(W - U) + \dot{W} && (22) \end{aligned}$$

Following Pissarides (2000), the wage agreed in the j-th employer-employee match results from a process of Nash bargaining in which each counterpart receives an amount of the surplus from the match proportional to their relative bargaining strength (denoted by β and $1-\beta$ for worker and firm respectively), as in:

$$w_{mj} = \arg\max (W_j - U)^{\beta}(J_j - V)^{1-\beta} \tag{23}$$

where W_j denotes the value of the match from the worker's point of view (and is substantially the single match version of (22)) and J_j the same for the firm. U and V are not indexed by j since every agent on both sides of the matching process is too small to influence the rest of the market and thus regards its conditions as given.

The standard assumption of free entry ($V = \dot{V} = 0$) closes the model and help to derive the final equilibrium (steady-state) conditions for J, θ and w_m:

$$\begin{aligned} w_m &= (1-\beta)\eta w_m + \beta(y_m + \xi w_m \theta) && (24) \\ (r+\lambda)J &= (1-\beta)(y_m - \eta w_m) - \beta \xi w_m \theta && (25) \\ J &= \frac{\xi w_m}{q(\theta)} && (26) \end{aligned}$$

and the asset value of being unemployed in the city as:

$$rU = \eta w_m + \frac{\beta}{1-\beta}\xi w_m \theta + \dot{U} \tag{27}$$

while the net effect of inflows and outflows from the unemployment pool implies:

$$\dot{L_m} = \theta q(\theta)(L_c - L_m) - \lambda L_m. \tag{28}$$

Finally, a digression on the appropriate way to measure output is required. Since the labour market is characterized by search frictions, the part of output devolved to this activity is not picked up when measuring factor incomes. In other words there exists a wedge between output and value added. In steady state, the model implies the following relation between non-agricultural value added and *gross* output:

$$\Upsilon_m = w_m L_m + (r+\delta)K_m = Y_m - \frac{(r+\lambda)}{\lambda} c v L_c \tag{29}$$

where the last term makes explicit the loss of non-agricultural output due to the assumption of costly vacancy posting. An expression similar to the one above, but in the context of a model with taxes and severance payments, can also be found in Satchi and Temple (2009).

3.4. Migration

To close the model, the migration decision has to be analyzed. Workers are assumed to be forward-looking in their migration choice in the sense that at every point in time they can decide to migrate to the non-agricultural sector if the expected value of being there is higher, and they will continue to migrate until the following arbitrage condition holds:

$$rA = rU \tag{30}$$

where U has been defined above and $rA = w_a + \dot{A}$ defines the asset value of being employed in agriculture (A), which corresponds to the agricultural wage, given perfect competition assumed in this sector's labour market, plus the expected capital gain from changes in the valuation of the asset during adjustment.

Noting that (30) holds also in rate of change ($\dot{A} = \dot{U}$) and substituting relevant expressions, the migration condition will take the form:

$$w_a = \eta w_m + \frac{\beta}{1-\beta}\xi w_m \theta \tag{31}$$

The set of relations that fully describes the economy is therefore constituted by equations (9), (11), (12), (20), (19), (15), (28), (63), (64), (26) and (31). The system is reported below for convenience.[16]

State variables:

$$\begin{aligned} \dot{K_m} &= s(\Upsilon_m + p_a Y_a) - \delta K_m && (32) \\ \dot{L_m} &= \theta q(\theta)(L_c - L_m) - \lambda L_m && (33) \\ & && (34) \end{aligned}$$

Jump variables:

$$(r+\lambda)J = (1-\beta)(y_m - \eta w_m) - \beta\xi w_m \theta + \dot{J} \tag{35}$$

[16] In principle (2), should be added to the system, but, since the price of land jumps at each instant to whatever value equalizes the returns to the different assets, and it does not play any role in the other equations, results are not affected, and 2 can be safely disregarded in the numerical simulation, thus it is not reported here.

Intra-temporal equations (to be satisfied at every point in time):

$$
\begin{aligned}
J &= \frac{\xi w_m}{q(\theta)} && (36)\\
w_m &= (1-\beta)\eta w_m + \beta(y_m + \xi w_m \theta) && (37)\\
w_a &= \eta w_m + \frac{\beta}{1-\beta}\xi w_m \theta && (38)\\
r+\delta &= \mu \frac{Y_m}{K_m} && (39)\\
y_m &= (1-\mu)\frac{Y_m}{L_m} && (40)\\
w_a &= p_a(1-\alpha)A_a^{-\rho}\left(\frac{Y_a}{L_a}\right)^{1+\rho} && (41)\\
r_a &= p_a \alpha A_a^{-\rho} Y_a^{1+\rho} && (42)\\
\frac{\lambda_p}{1-\lambda_p} &= \frac{(1-s)\Upsilon_m - s p_a Y_a + \gamma_m}{p_a(Y_a - \gamma_a)} && (43)\\
& && (44)
\end{aligned}
$$

where:

$$
\begin{aligned}
q(\theta) &= M_p \theta^{-\gamma} && (45)\\
p_a Y_a &= w_a L_a + r_a && (46)\\
\Upsilon_m &= w_m L_m + (r+\delta)K_m && (47)
\end{aligned}
$$

4. Growth accounting with search frictions

In this section, I present a decomposition of TFP growth for the whole economy when one of the two sectors is characterized by search frictions. The main strategy of the decomposition follows that developed in Monteforte (2011), regarding the presence of unemployment and the possibility of increasing returns to scale. But it also has to take into account the fact that labour is now measured in efficiency units and the presence of a wedge between the non-agricultural wage and the corresponding marginal product of labour. The assumption of free entry in posting new vacancies assures that the wedge coincides with the amount of recruiting costs firms have to pay. However, measures of recruiting costs are not registered in national accounts, which instead give only a measure of value added. Therefore, a correct growth accounting exercise should consider the decomposition in terms of value added. Furthermore, since the relative price changes over time, value added has to be deflated, following an approach set out by Temple and Woessmann (2006).

In the current model total nominal output is given by the sum of output in each sector as given in

(1), which is restated here for convenience:

$$Y = Y_m + p_a Y_a$$

Agriculture is perfectly competitive, therefore agriculture output coincides with value added: $p_a Y_a = w_a L_a + r_a$. The situation in non-agriculture is different. Individual firms operate under constant returns to scale, hence Euler's theorem holds, and aggregating at sectoral level:

$$Y_m = y_m L_m + (r + \delta) K_m \tag{48}$$

Re-expressing equation (25) more compactly to highlight the wedge between the marginal product and the non-agricultural wage as:

$$y_m = w_m + [(r + \lambda)J - \dot{J}] = w_m + \Pi \tag{49}$$

total output could be rewritten in terms of value added and recruiting costs in the following way:

$$\begin{aligned} Y &= p_a Y_a + Y_m \\ &= w_a L_a + r_a + w_m L_m + (r + d) K_m + [(r + \lambda)J - \dot{J}] L_m \\ &= \Upsilon + \Pi L_m \end{aligned} \tag{50}$$

where Υ denotes value added and includes the first four terms, while the last one is recruiting costs ($\Pi \equiv (r + \lambda)J - \dot{J}$). With this way of rewriting total output, it may be more accurate to speak about operating profits, since here I am effectively using the difference between the marginal product of labour and the wage paid by the firm. However, it can be easily shown that this way of expressing total output could be rewritten considering recruiting costs explicitly, in the same fashion as the value added equation given in (29). The underlying mechanism may be explained in the following way: when opening up a vacancy, entrepreneurs face some costs which they have to pay upfront, possibly financing them with bank loans. When the vacancy is filled profits are used to repay the loans initially taken and the assumption of free entry guarantees that, on average, profits earned are just enough to repay those loans, thus exhausting all available resources from the match in an ex ante sense.

Thus, the growth rate of nominal output net of recruiting costs will be given by:

$$\frac{\dot{\Upsilon}}{\Upsilon} = \frac{Y}{\Upsilon}\frac{\dot{Y}}{Y} - \frac{\Pi L_m}{\Upsilon}\frac{\dot{L_m}}{L_m} - \frac{\Pi L_m}{\Upsilon}\frac{\dot{\Pi}}{\Pi} \tag{51}$$

so value added growth is equal to growth in total output net of growth in recruiting costs, which in turn is due to the growth in both the number of workers hired and the unit cost of hiring.

On the other hand, I define real value added growth as the nominal one net of the growth rate of prices, which, remembering that nominal value added can be expressed as the sum of sectoral incomes ($\Upsilon = \Upsilon_m + p_a Y_a$), could also be reinterpreted as a Divisia output index (Temple and Woessmann, 2006):[17]

$$\frac{\dot{\Upsilon_{real}}}{\Upsilon_{real}} \equiv \frac{\dot{\Upsilon}}{\Upsilon} - \frac{p_a Y_a}{\Upsilon}\frac{\dot{p_a}}{p_a} = \frac{\Upsilon_m}{\Upsilon}\frac{\dot{\Upsilon_m}}{\Upsilon_m} + \frac{p_a Y_a}{\Upsilon}\frac{\dot{Y_a}}{Y_a} \tag{52}$$

So subtracting the term relative to the growth of prices $\frac{p_a Y_a}{\Upsilon}\frac{\dot{p_a}}{p_a}$ from both sides of (51), I get to the decomposition of growth in real output, net of recruiting costs:

$$\frac{\dot{\Upsilon_{real}}}{\Upsilon_{real}} \equiv \frac{\dot{Y}}{Y}\frac{Y}{\Upsilon} - s_\pi \frac{\dot{\Pi}}{\Pi} - s_\pi \frac{\dot{L_m}}{L_m} - s_a \frac{\dot{p_a}}{p_a} \tag{53}$$

where $s_a \equiv p_a Y_a/\Upsilon$ and $s_\pi \equiv \Pi L_m/\Upsilon$ define shares of agriculture and recruiting costs in total income respectively.

Leaving for the appendix full details of the decomposition of the right hand side, here I report the final result which has been used in the calibration to quantify the relative importance of the different components of the Solow residual. Assuming that a standard growth accounting exercise would use information on output shares and growth rates of factor inputs, the resulting growth in the Solow residual can be expressed as the sum of the following components:

$$\frac{\dot{TFP}}{TFP} = (1 - s_a)\frac{\dot{A_m}}{A_m} + s_a \frac{\dot{A_a}}{A_a} \tag{54}$$

$$+B_1 \frac{\dot{m_e}}{m_e} \tag{55}$$

$$+s_\pi \frac{\dot{A_m}}{A_m} - s_\pi \frac{\dot{\Pi}}{\Pi}. \tag{56}$$

where $\omega \equiv (w_a L_a + w_m h L_m)/\Upsilon$ and $\nu \equiv r_a R/\Upsilon$ denote the income shares of labour and land respectively; and $B_1 \equiv \frac{\omega(d-1)(1-a-u_n)}{a+d(1-a-u_n)}$ is a weighting parameter which depends on the wage differential across the two sectors ($d = w_m/w_a$), the shares of agriculture employment (a) and non-agricultural unemployment in the total labour force ($u_n \equiv L_u/L$), as well as on ω and s_π, which have been already defined.[18]

The first term on the right hand side, numbered (54), is what I call the *pure efficiency effect*: it captures the part of the Solow residual which is due just to sectors' TFP growth, and it is a weighted sum with weights corresponding to sectoral shares in total value added.

The effect of productivity gains due to reallocation of labour from one sector to the other is captured by the second component (55), where $m_e \equiv L_m/(L_a + L_m)$ denotes the share of non-agricultural employment in total employment. However, the presence of search frictions require an adjustment

[17] Given the assumption of consumers with Stone-Geary preferences, in the context of the current model, this reinterpretation is best seen as an approximation. Instead, in a model assuming standard Cobb-Douglas preferences the approximation turns into equality.

[18] Explicit derivations for each of the parameters mentioned can be found in the appendix to this paper.

due to the part of output which has to be used in the recruitment process and cannot be recovered elsewhere, thus the two terms in (56).

One final note is in order regarding the proper way to measure the reallocation effect in the presence of search frictions. The components in (54) - (56) do not take into account the fact that since parameter B_1 is based on the observed wage differential, some of the growth bonus given by reallocation may be understated, given the wedge between the non-agricultural wage and the non-agricultural marginal product. A better sense of the true growth bonus from reallocation could be given by rewriting the decomposition above in terms of a marginal product differential across sectors. Although having the disadvantage of being less measurable with real world data, in the context of the simulated model of this paper, this version of the decomposition will give a more accurate idea of the importance of structural transformation in aggregate productivity improvement. Leaving for the appendix the details of the actual derivation, the decomposition of the Solow residual using the marginal product differential is as follows:

$$\frac{T\dot{F}P}{TFP} = (1-s_a)\frac{\dot{A_m}}{A_m} + s_a\frac{\dot{A_a}}{A_a} \tag{57}$$

$$+\tilde{B}_1\frac{\dot{m_e}}{m_e} \tag{58}$$

$$+s_\pi\frac{\dot{A_m}}{A_m} - C_1\frac{\dot{m_e}}{m_e} - s_\pi\frac{\dot{\Pi}}{\Pi} \tag{59}$$

where everything is defined as above, but now with parameter $\tilde{B}_1$ being calculated in the same way as B_1 but using the marginal product differential, and the new term in (59) based on the new weighting parameter defined as $C_1 \equiv s_\pi(1-u_n)/(a+d_{mpl}(1-a-u_n))$.

5. Calibration and results

In this section the choice of parameters values is discussed first, moving then to the analysis of results regarding the transitional dynamics of the model and its implications for Spanish structural change. Some counterfactual experiments will also be described in order to highlight the role played by increases in sectoral TFP and modifications in labour market institutions as potential drivers of structural transformation in postwar Spain.

5.1. Choice of parameter values

The set of the model's parameters can be divided in two subgroups: those imputed directly from available data, and those determined endogenously in order for the model to replicate some observed characteristics of the Spanish economy, either at the end or at the beginning of the time period of reference (output and employment shares in particular). The data used for the calibration come from two main sources: the EU-KLEMS database (O'Mahony and Timmer, 2009), used for most of the sectoral figures (spliced with data from Garrido Ruiz (2005) and historical national accounts (Smits et al., 2009) for sectoral value added shares prior to 1970); and the CEP-OECD dataset (Nickell, 2006) for non-agricultural labour market variables. All parameter values are summarized in tables 1 to 3.

5.1.1. Calibrated parameters

The calibration strategy assumes the economy to be in equilibrium both at the beginning and at the end of the transition. The model is solved at the final steady state (year 2005), matching the agriculture employment share and the unemployment rate in that year (7% and 9.2% respectively) as well as the average duration of a vacancy in non-agriculture (approximately 4 weeks), to get the implied values for the preferences parameter λ_p, the relative cost of keeping a vacancy open ξ (roughly 30% more than the non-agricultural wage, see table 4), and the efficiency of matching M_p (0.1 on a weekly basis, see table 3).[19]

The same approach was taken in order to back out the main parameters in the sectoral production functions: ρ, α and μ (top panel of table 2). The last two have been chosen to match the respective sectoral labour income shares in 2005 (0.7 and 0.66 respectively). In the KLEMS data the non-agricultural labour income share does not vary much, fluctuating around the standard value of 0.66, which was therefore chosen as reference point for the 2005 figure, justifying also the adoption of the Cobb-Douglas technology for production in that sector. The situation for agriculture is different, where the data source for the choice of the income share to be matched is especially relevant given the greater measurement difficulties in quantifying labour compensation of self-employed farm workers. In this respect, the KLEMS database addresses the issue in the standard way of imputing self-employed hourly compensation with that of employees. However, this problem might be relevant for sectors such as agriculture, where the self-employed are present on a larger scale and are likely to experience lower hourly compensation, leading to underestimates of the relative labour share.[20] Garrido Ruiz (2005), instead, provides data on Spanish agricultural labour shares corrected using available information on farmers' mixed income. Thus, the latter has been used as data source for the agriculture labour share (specifically table 1, which reports a value of 0.7 in 2005), and given the observed variation in the data (a reduction of 20 percentage points in the period 1955-1983 and a later increase of 10 p.p.), the CES form has been chosen for the production technology in agriculture. The other key parameter of the CES production function, ρ, which is related to the elasticity of substitution between land and labour ($\rho = (1-\sigma)/\sigma$), has been chosen to yield a variation in the agriculture labour income share reasonably

[19] The average vacancy duration (0.9652 months) has been calculated as the stock of vacancies at the end of the month over the outflow, using data from the Spanish Ministry of Labour (www.redtrabaja.es).

[20] Timmer et al. (2007) report that early research with US data suggests that the ratio of self-employed compensation to that of employees' should rather be 0.8, while Gollin (2002) discusses the importance and the consequences of correctly measuring labour compensation, proposing three adjustments to take care of self-employment. Finally, Carrasco and Ejrnæs (2003, p. 6) report that according to OECD data Spain is one of the countries with the highest share of agricultural self-employment, although it has decreased from 42% to 22% in the period 1979-1995.

similar to that observed in the data.[21] In a similar vein, the parameter values in the consumers' Stone-Geary utility function (γ_a and γ_m) have been chosen to match respectively the agriculture employment share and the unemployment rate in 1950 (top panel of table 1).[22]

In general, the calibration approach has sought to use as much information as possible at the end of the reference period because of the greater availability and reliability of data. The model was then solved in an initial steady-state in which all exogenous parameters were at their starting values, leaving the simulation to determine all transitional dynamics.

Table 1: Parameter values - baseline case - Utility and sectoral efficiency

	Parameter	**Value**
Stone-Geary utility parameters:		
Subsistence consumption	γ_a	0.33**
Urban home production	γ_m	4.76***
Exponent in Stone-Geary utility	λ_p	0.96*
TFP parameters:		
Urban TFP lower bound	$\underline{A_m}$	0.93
Urban TFP upper bound	$\overline{A_m}$	2.49
Urban TFP yearly speed of adjustment	ψ_m	0.14
Agr TFP lower bound	$\underline{A_a}$	0.99
Agr TFP upper bound	$\overline{A_a}$	5.26
Agr TFP yearly speed of adjustment	ψ_a	0.04

* Value backed out to match agricultural employment share in 2005. See text for details.

** Value backed out to match agricultural employment share in 1950. See text for details.

*** Value backed out to match unemployment rate in 1950. See text for details.

5.1.2. Exogenous parameters

The conditions derived in the previous sections are valid in equilibrium. Since the model is aimed to represent the dynamic path of structural change, with special reference to the Spanish post-war

[21] Table 2 reports the implied value for the elasticity of substitution σ.

[22] To be more precise, because of data availability, the relevant figure for unemployment refers to the average rate observed in the 1950s, as provided by Martin (1994), 2.1 percent. The agriculture employment share in 1950 was 51.9 percent (data from van Ark and Crafts, 1996).

Table 2: Parameter values - baseline case - Production

	Parameter	Value
Agr elasticity of substitution	σ	1.2**
Exponent on capital in non-agr production function	μ	0.334*
Agr CES distribution parameter	α	0.213*
Labour Force (logs) lower bound	$\underline{\ell}$	-0.6
Labour Force (logs) upper bound	$\overline{\ell}$	0
Labour Force (logs) yearly speed of adjustment	ψ_ℓ	0.22
Depreciation rate	δ	0.06
Saving rate	s	0.21

* Values backed out to match labour income shares in 2005. See text for details.

** Value backed out to match variation in labour income shares in 1950. See text for details.

experience, I need to derive the counterparts of (24) and (25) which are valid also out of the steady state. In this respect, the particular situation that Spain has experienced right at the onset of the Second World War and during its post-war period has to be taken into account.

From the viewpoint of the model previously described, the rigid state control over the market exerted by the dictatorship and the substantially higher entry costs faced by entrepreneurs could be partially captured with the assumption of an exogenous change over time in the parameter ξ. In particular, a downward sloping path is consistent with the gradual transition from autarky to market-oriented polices which characterized the 1950s and with the acceleration implied by the major reforms at the end of the decade.[23] In a similar (but opposite) fashion, an upward sloping path for the parameters capturing the replacement ratio η, and worker bargaining power β, can help in capturing the parallel evolution of industrial relations in Spain, with workers gradually being able to extract a greater share of the match surplus as the control of the dictatorship weakened.

For all of the time-varying parameters, the particular form of the time path chosen was logistic, whose differential equation takes the form:

$$\dot{z} = \psi_z(z - \underline{z})(\overline{z} - z) \tag{60}$$

where z denotes the parameter under consideration, whose dynamics start from an initial value close to

[23] In fact, Prados de la Escosura et al. (2011) argue that the moderate changes of the early 1950s were particularly important as a prerequisite for the further reforms of the end of the decade in setting the stages for the sustained growth of the "*Spanish miracle*".

the lower bound $\underline{z}$, and reach the upper bound $\overline{z}$ at a speed determined by ψ_z.[24] The choice is flexible enough to adapt to many of the time paths considered.

Furthermore, assuming time-varying bargaining power implies also a modification in the derivation of the out-of-steady-state counterparts of (24) and (25). With a time-varying β, the standard first-order condition for Nash bargaining ($\beta J = (1-\beta)(W-U)$) does not hold also in rates of change, and assumes instead the slightly more complicated form:

$$\beta \dot{J} + \dot{\beta} J = -\dot{\beta}(W-U) + (1-\beta)(\dot{W} - \dot{U}) \tag{61}$$

$$\Rightarrow (\dot{W} - \dot{U}) = \frac{\beta}{1-\beta}\dot{J} + \frac{J}{(1-\beta)^2}\dot{\beta} \tag{62}$$

implying in turn the following equations for the transitional dynamics of w_m and J:

$$w_m = (1-\beta)z + \beta(y_m + \xi w_m \theta) - \frac{\dot{\beta}}{(1-\beta)}J \tag{63}$$

$$\left[(r+\lambda) - \frac{\dot{\beta}}{1-\beta}\right] J = (1-\beta)(y_m - \eta w_m) - \beta \xi w_m \theta + \dot{J} \tag{64}$$

which respectively are the two out-of-steady state forms of (24) and (25).

Together with the parameters capturing the change in labour market institutions, a dynamic path as in (60) is imposed on the evolution of sectoral TFPs. The former vary over time to capture some of the main features of the Spanish transition from dictatorship to democracy, and together with sectoral TFPs induce dynamics into the system leading to the transitional adjustment, that will be studied in the following section. But, before doing that, in what follows the strategy for the estimation of (60) is explained for each time-varying parameter.

Parameter values for TFP transitions have been estimated by non-linear least squares using time series of sectoral TFP built using growth accounting techniques on data coming from the KLEMS database (which, among others, provides sectoral disaggregated data on output and factors' compensations). Although the time period covered in KLEMS is shorter than the one considered here (it starts from 1970), the clear S-shaped pattern displayed by agricultural TFP (the dash-dotted line in figure 1) justifies the form of the dynamic equation chosen. Although the pattern for non-agricultural TFP in the KLEMS data is less pronounced, the same logistic form was used, fitting parameter values accordingly. [25]

Data points for the period 1950-1970 (not available in KLEMS) were derived applying Domar aggregation to the estimates for total economy TFP growth provided in Prados de la Escosura and Rosés (2009).[26] The implied parameter values for the sectoral TFP speeds of adjustment, as well as

[24] The only exception being the vacancy opening costs parameter, ξ, which decreases over time.

[25] A more detailed discussion of the dynamics of sectoral TFPs and their derivation is provided in the appendix.

[26] Value added shares prior to 1970 were taken from Garrido Ruiz (2005) and the historical national accounts database from the Groningen Growth and Development Centre (www.ggdc.net).

upper and lower bounds, are given in the lower part of table 1, with starting values for both A_a and A_m which, without loss of generality, have been normalized to 1 and final implied values reported in table 4.

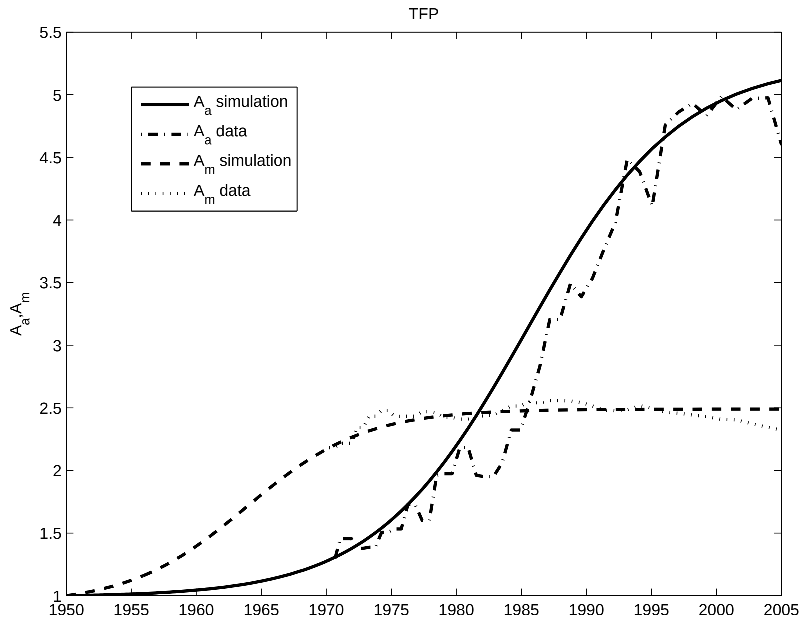

Figure 1: TFP data and model

A similar approach (the specification of a logistic) has been adopted for the non-agricultural labour market institutional variables, with the caveat of the lack of direct usable measures along these dimensions. Nonetheless, values have been chosen in order to reflect the evolution of the labour market institutions outlined earlier, with particular reference to the effects deriving from the transition from dictatorship to democracy.

Therefore, the exogenous path of workers' bargaining power is increasing over time to reflect progressive concessions made to workers starting from liberalization in 1959, and the legalization of unions subsequent to the end of the dictatorship. In particular, from an initial value of 0.1, the parameter β reaches the upper bound of 0.5 by the early 1990s, a standard value usually adopted in the search and matching literature. This could be considered as a rather conservative choice, given the control over bargaining exerted by workers' unions in modern Spain and the complete coverage their agreements have, which are automatically extended to non-unionized workers. The functional form is again, as for TFP, of the logistic type expressed by equation (60). The speed of adjustment has been chosen in order for the turning point to match the year of maximum growth in worker bargaining power, which I assume to be 1977, the year of the Moncloa agreements, where major steps had been undertaken for wage moderation, following the steady increases of the years immediately after General Franco's death.[27] All parameters are summarized in tables 3 and 4.

In the interest of realism and following the same argument above, firms' recruiting costs, ξ, whose final value was backed out in the way described in the preceding section, are assumed to take a downward sloping path, again of the logistic type. The assumption here is that entry costs in 1950 were five times higher than those in 2005 (table 4) in order to reflect the initial international isolation of Spain and the gradual process of liberalization and opening to foreign trade initiated by the 1959 *Stabilization and Liberalization Plan*.[28] Bounds and speed of adjustment have been chosen in order for the inflection point of the logistic curve (where reduction in entry costs starts to slow down) to coincide with the end of the Spanish golden age, taken to be 1974 (table 3).

The selection of parameter values for the dynamics in the replacement ratio η follows the historical evidence in the following way. The upper bound $\overline{\eta}$ was set according to Bentolila and Jimeno (2006), who provide an average figure for the period 1983-94, when replacement ratios reached their highest values. The lower bound was instead imposed to guarantee an initial value for the replacement ratio as low as 0.1 (table 4): unemployment benefits were introduced only in 1961. The speed of adjustment ψ_η has been calculated to match the extent of unemployment benefits in the year of their introduction (1961).

The last time-varying parameter to be discussed is total labour force L (expressed in logs as ℓ). Using OECD data, the size of the Spanish labour force has increased by roughly 60% in the second part of the last century, thus parameters in equation (60) have been selected to reflect this overall increase (table 2, where without loss of generality, the final level has been normalized to unity). The pattern chosen however is less representative of the actual historical experience, since the labour force exhibited accelerating growth throughout all the period considered (the path is convex), while here for computational reasons I assume a bounded function. Nevertheless, what matters for labour force growth in this context is more the overall change than its ultimate pattern.[29]

Finally, the choice of four more parameters remains to be discussed, namely the depreciation rate δ, the saving rate s, the elasticity of matches with respect to unemployment γ and the separation rate λ (values for the first two can be found in table 2 and for the latter two in table 3). These are the parameters assumed to be constant over time. The saving rate has been set to 0.21, the average value of gross investment expenditure as a share of GDP over the entire 1950-2005 period; while the depreciation rate refers to those used in the KLEMS database, which actually distinguishes rates of depreciation by asset type (but not over time), and has been chosen with particular reference

[27] The functional form used to calculate parameter values is $Z(t) = Z_L + \frac{Z_H - Z_L}{1 + A\exp(-\phi(Z_H - Z_L)t)}$ where the constant $A \equiv (Z_H - Z_L)/(Z(0) - Z_L) - 1$.

[28] Although the choice of the initial magnitude is potentially controversial, given the lack of historical data on firms' recruiting costs, the effects on the evolution of sectoral structure are modest. As a robustness check, the model has been simulated assuming in 1950 the same relative cost of vacancies as that backed out in 2005, and results in terms of sectoral employment shares do not vary much. Obviously variables within the labour market do change, in a fashion similar to that described in the counterfactual simulations related to change in labour market institutions.

[29] We leave to further research the introduction of labour force growth also in the steady state.

to infrastructure and machinery.[30] The elasticity of matches to unemployment has been set to 0.5, a standard value in the literature. As for the job separation rate, an annualized value of 0.2 has been chosen, based on data on continuous-time exit rates from employment computed for Spain by Petrongolo and Pissarides (2008).

Table 3: Parameter values - baseline case - non-agr labour market

	Parameter	Value
Job destruction rate	λ	0.2
Weekly matching efficiency	M_p	0.1*
Elasticity of matches to unemployment	γ	0.5
Labour market institutions:		
Workers' bargaining power lower bound	$\underline{\beta}$	0.099
Workers' bargaining power upper bound	$\overline{\beta}$	0.5
Yearly speed of adjustment of β	ψ_β	0.55
Replacement ratio lower bound	$\underline{\eta}$	0.09
Replacement ratio upper bound	$\overline{\eta}$	0.75
Yearly speed of adjustment of η	ψ_η	0.38
Vacancy opening cost lower bound	$\underline{\xi}$	1.31
Vacancy opening cost upper bound	$\overline{\xi}$	6.6
Yearly speed of adjustment of ξ	ψ_ξ	-0.038

* Value backed out to match vacancy duration in 2005. See text for details.

5.2. Simulations

The model has been simulated using the relaxation algorithm described in Trimborn et al. (2008). All variables have been assumed to be in their steady state at the beginning of the period of reference. Transition is triggered by the dynamics in the exogenous time-varying parameters described in the previous section (starting and final values summarized in table 4). In this sense, the most important are the sectoral TFP parameters, whose evolution might be interpreted as a gradual adaptation to the world technology frontier, after the deadlock imposed by the regime and the war. In what follows results from simulations of the model are discussed, considering first a baseline case, in order to see how well the model captures certain features of the Spanish structural transformation, moving then

[30] Data from the Spanish national accounts, kindly provided by Leandro Prados de la Escosura.

Table 4: Initial and final conditions for exogenous state variables - baseline case

	Variable	Value
Workers' bargaining power in 1950	β	0.1
Workers' bargaining power in 2005		0.5
Replacement ratio in 1950	η	0.1
Replacement ratio in 2005		0.75
Vacancy opening cost in 1950	ξ	6.56
Vacancy opening cost in 2005		1.31*
Labour force in 1950	L	0.55
Labour force in 2005		1
Urban TFP in 1950	A_m	1
Urban TFP in 2005		2.49
Agricultural TFP in 1950	A_a	1
Agricultural TFP in 2005		5.13

* Value backed out to match unemployment rate in 2005. See text for details.

to some counterfactual experiments in order to evaluate the importance of sectoral TFP growth (the push-pull effects) and changes in labour market institutions in more detail.

5.2.1. Baseline model

Results from the baseline simulation are presented in the panels of figures 2 and 3. Starting first from the evaluation of the performance of the model with respect to actual data, the model in its baseline configuration is able to replicate quite accurately the Spanish process of structural transformation, as highlighted in the top left panel of figure 2 where the time path of the agriculture employment share is plotted.

The comparison of the results on the behaviour of the relative price to those observed in the data is also satisfactory. The relevant patterns are displayed in the top right panel of figure 2, where both series have been normalized to 1 in the year 2000.[31] In the data, the relative price displays erratic behaviour during the first decade when it first decreases up to 1955 and then increases till the end of the decade. Starting from the early 1960s onwards, the trend is clearly downward sloping. The behaviour of the relevant variable in the model is characterized by an initial steady increase up to the early 1970s, when the trend is reversed and becomes more coherent with that observed in the data.

[31] Data on sectoral deflators, kindly provided by Leandro Prados de la Escosura, were available only up to this date.

The model's results could be interpreted as a preliminary confirmation of the mechanism highlighted in Alvarez-Cuadrado and Poschke (2011), where the sequence of "first pull, then push" effects is extrapolated from the behaviour of relative prices over time: when the attractive force of higher wages determined by productivity improvements in the non-agricultural sector is the main determinant of structural transformation (the pull effect), the relative price of the agricultural good increases; when, instead, the release of labour from agriculture, as a consequence of combined growing agriculture TFP and a low elasticity of demand for the agricultural good, gains importance for structural change, it translates into a falling relative price (the push effect).[32]

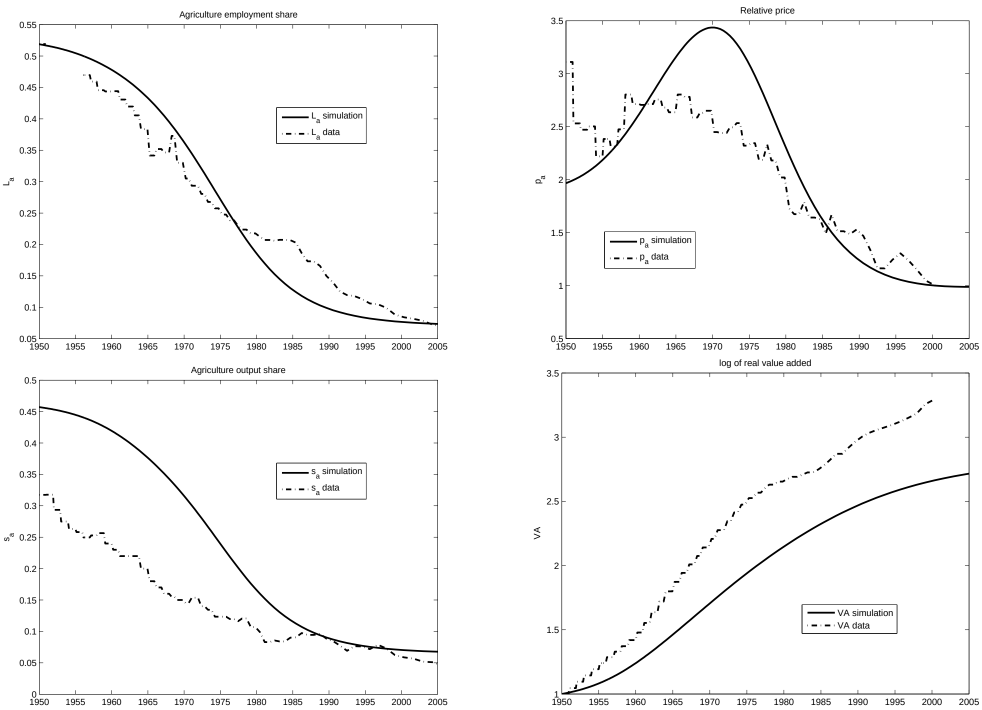

Figure 2: Structural change - baseline model

On the other hand, when looking at structural change from the point of view of the share of agriculture in total value added (the bottom left panel of figure 2) the performance of the model is less satisfactory. In this case, however, the data might be thought as less reliable, as there often are difficulties in proper measurement of agricultural value added, not least given blurred boundaries between output produced for the market and home production or exact imputation of land rents, as pointed out by Herrendorf and Schoellman (2014). Nevertheless, for the last 20 years the model does perform well also along this dimension.

[32]Alvarez-Cuadrado and Poschke (2011) define the relative price using the price of food as numeraire, thus their original statement is reversed: increasing prices are evidence of "push" and decreasing prices of "pull". Furthermore it must be also noted that in the case of this model the pull effect comes from the interwoven action of increasing non-agricultural TFP and capital accumulation, since capital is assumed to be a factor of production only in manufacturing.

Similar considerations come to mind when looking at the lower right panel of figure 2, where the path of real GDP is plotted against that actually observed in the data: the model underestimates GDP growth along all the path.[33] One of the explanations that can be addressed as the reason for this undesirable pattern relates to the simplifying assumptions of the model. In particular, the model uses units of labour in per-capita terms implicitly assuming no differences over time and/or across sectors in terms of efficiency. This assumption is consistent with the evidence on the time evolution of the combination of human capital and average working hours in Spain. Educational attainment and average working hours moved in the opposite direction by the same magnitude in the period considered. However, one possibility could be, as suggested in de la Fuente et al. (2003), that social returns to schooling in Spain are higher than the private returns estimated with standard Mincerian wage equations, thus suggesting an overall increase in efficiency units rather than constancy over time.

Moving to the analysis of the labour market in more detail, the main consideration regards the observed path of national unemployment (upper left panel of figure 3). Structural change does account for at least a part of the increase in unemployment of the second half of the century: unemployment is increasing over time, though not by the magnitude observed in the data. Put in another way, search frictions can indeed explain the low levels of unemployment observed in the 1950s, but can only partially explain the overall increase in Spanish unemployment subsequent to the end of the dictatorship.

Looking at the solid line in the figure in more detail, in the model nearly all of the increase in unemployment happens within the first 30 years, the period of greater structural change in Spain: an increasing number of workers left the agriculture sector and migrated to the cities with prospects of better salaries, guaranteed by a sector that was experiencing faster productivity growth (and capital deepening), as a consequence of the convergence process initiated by the gradual embrace of free market policies during the second part of Franco's regime. By the early 1980s the effect of structural change on unemployment in the model ends, while the historical evidence registers a further increase, with unemployment doubling further in the first half of the decade, and remaining at consistently higher levels for the rest of the period (fluctuations are consistent with the European cycle).

A possible explanation for this inability of the model to account for the increase in the later period is related to the fact that it does not incorporate the introduction of fixed-term and training contracts that are widely believed to have increased Spanish unemployment from the 1980s onwards.[34] In the current model jobs are homogeneous with respect to the type of contract, and each match has an equal chance of ceasing per unit-time, namely the job destruction rate λ. A search model of the labour market explicitly incorporating heterogeneous contracts might be able to account more successfully for

[33] Levels of real value added have been derived applying the definition in (52), while those observed in the data come from figures kindly provided by Leandro Prados de la Escosura.

[34] For an extensive discussion of the employment rationalization and labour shedding that characterized the Spanish labour market between the end of the 1970s and the first half of the 1980s, as a consequence of the increase in labour market flexibility (together with the oil shocks and effects of the termination of the dictatorship), see Bentolila and Blanchard (1990) as well as Bentolila and Jimeno (2006).

the subsequent increase in Spanish unemployment.[35]

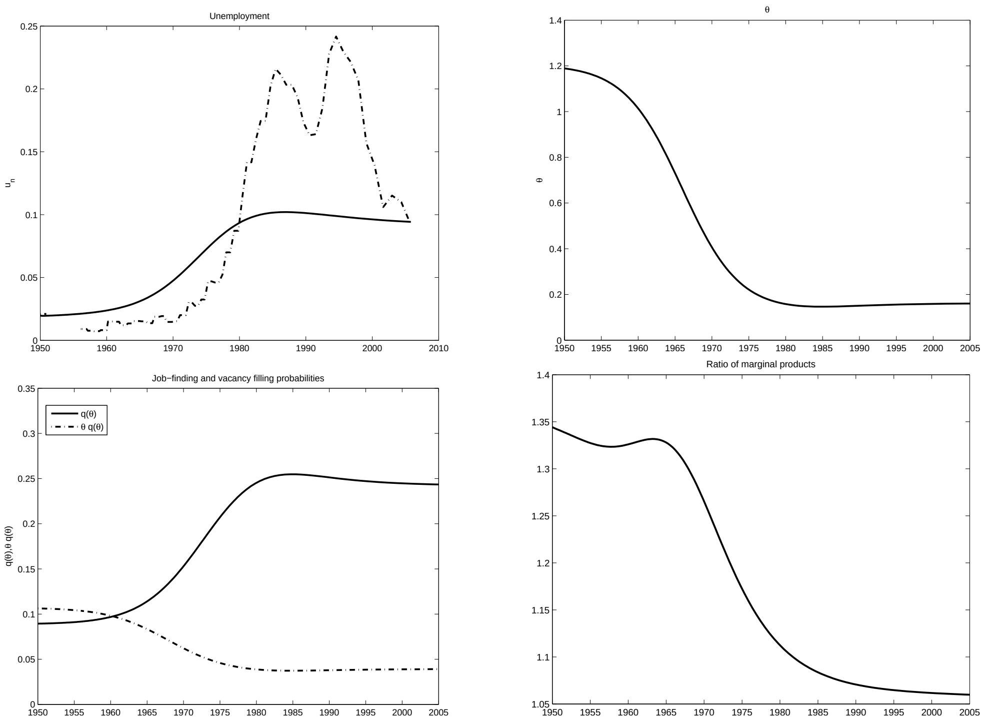

Figure 3: Urban labour market - baseline model

The behaviour of the labour market during the transition is summarized in the remaining panels of figure 3. In the model agents are fully forward-looking, in that they are able to accurately forecast their future income streams. When TFP variables start to change over time, workers and firms update their behaviour accordingly. In the first two decades, non-agricultural TFP growth is higher than the relevant figure in agriculture, making it profitable for firms to open more vacancies in the city, which in turn increases the lifetime utility of searching for a job in the non-agricultural sector, because of a lower duration of unemployment spells. Confirmation of this process can be found in the second and third panel of figure 3, where at the beginning the labour market is quite tight (there are more vacancies than unemployed workers), which is reflected in both a lower hazard rate of filling a vacancy (low $q(\theta)$) and a higher job-finding probability (high $\theta q(\theta)$). Unemployment is at its minimum level (first panel in 3), and the agriculture employment share starts to decrease (figure 2).

Over time, however, the effects of Engel's law and TFP increases in agriculture prevail, leading to a further release of workers from agriculture, even if the employment prospects in the non-agricultural sector are less good: indeed, non-agricultural labour market tightness reduces substantially, implying higher unemployment spells (decreasing $\theta q(\theta)$) and lower duration of vacancies, which now are matched

[35]With special reference to the Spanish case, recent examples include Bentolila et al. (2010) and Costain et al. (2010).

with unemployed workers at a higher rate (increasing $q(\theta)$). Consequently, the initially high marginal product differential between the two sectors decreases substantially (last panel of 2).

These effects are also amplified by the transition from dictatorship to democracy and a free market economy, with its related change in labour market institutions (increase in worker bargaining power, and the increase in unemployment benefits, whose effects are partially counteracted by lower recruiting costs). In the long run, structural transformation and changes in labour market institutions imply a substantial increase in unemployment, which, at the end of the transition, will be more than four times higher than at the beginning.

Overall, the results from the baseline simulation suggest that the model is able to replicate the process of Spanish structural transformation, which in turn is found to be partly responsible for the increase in unemployment registered in the 1970s. Furthermore, the model is consistent with previous research describing the dynamics of structural transformation as a sequence of "first pull, then push" effects (Alvarez-Cuadrado and Poschke, 2011).

5.2.2. Push or pull?

In this and the following section two counterfactual experiments will be respectively discussed. Their aim is to: (i) further investigate the role of sectoral TFP growth in structural change; and (ii) highlight the implications of the model when there are modifications in labour market conditions, following the Spanish transition to democracy. In this section I analyze the first set. To answer this question I first simulate the model by "switching off" the exogenous change in agriculture's TFP, keeping it fixed at its initial level; then I do the same for non-agricultural TFP; and finally I analyze the case in which both of them are constant over time, and structural transformation is dependent only on capital deepening in non-agriculture.

Throughout all counterfactual experiments, all the other parameters of the model are treated in the same way as in the baseline case, except for the parameter whose effect I am actually investigating. Thus, those parameters assumed to be constant over time in the baseline simulation, will be constant also in the counterfactual experiments; and all the time-varying parameters, except for that one whose growth has been "switched off", will keep displaying their dynamics.[36]

Results are summarized in the panels of figure 4, where I also report the baseline case for comparison. In particular, results of key variables for structural transformation are displayed in the first column, while the second column looks at the key labour market variables in more detail.

In the first experiment I "switch off" A_a, agriculture TFP. As can be seen from the path of the dash-dotted line in the top panel of the first column in figure 4, keeping productivity improvements confined just to non-agriculture makes a noticeable difference. Indeed, the agriculture employment share almost halves during the transition, but it is still far from reaching the low levels actually registered in the data

[36]Among the time-invariant parameters: the depreciation rate δ, the saving rate s, the job separation rate λ and the elasticity of matches to unemployment, γ.

and in the baseline model. In this case, much of the structural transformation actually happens later on, mainly between the early 1970s and the end of the 1980s, suggesting it has been driven more by capital accumulation than non-agricultural TFP, which instead increases quite quickly at the beginning and then slows down.

Obviously, the same pattern is detectable also when looking at the agriculture output share (middle panel of first column in the same figure). Since more labour remains allocated to the low-productivity sector, agriculture accounts for a larger share of a smaller cake: the direct consequence of hindering TFP growth in agriculture is, in fact, a lower level of GDP with respect to the baseline. The behaviour of the relative price of the agricultural good confirms that only the "pull" effect is at work, since the relative price is increasing almost monotonically (lower panel of the first column of figure 4).

Looking in more detail at the labour market through the panels in the second column of figure 4, the absence of any change in A_a understandably has only the effect of reducing overall national unemployment, simply because of a smaller size of the sector where it arises (top panel). But the labour conditions within the sector are virtually unchanged, as confirmed by the almost identical paths for labour market tightness and the hazard rate of filling a vacancy (middle and lower panels). This is the case also for the other two experiments I am going to discuss: productivity changes affect the labour market only by modifying the relative size of the two sectors, but have no influence on non-agricultural labour market conditions (all lines in the panels of the second column overlap). Thus, in the discussion of the other two experiments I will only concentrate on the variables displayed in the panels of the first column.

The second experiment analyzes the effect of "switching off" growth in the other TFP parameter, A_m. Its impact on the model is depicted by the dashed lines in figure 4. In this case, the magnitude of structural change is similar to the baseline, both in terms of employment and output shares. The relative price falls over time, which is in accordance with the fact that only TFP in agriculture is growing. However, one should be careful in interpreting this as evidence of "push" effects: as briefly mentioned earlier, in the context of this model there is another force which attracts workers to non-agriculture, namely capital accumulation. Since capital is used as a factor of production only in the non-agricultural sector, "switching off" A_m does not isolate the "push" effect: indeed, even in this case structural transformation actually results from the combined effect of "push" and "pull", because of TFP growth in agriculture, and capital deepening.

To derive an insight into whether capital deepening in the non-agricultural sector is important to structural change, I run a third simulation in which I "switch off" growth in both A_a and A_m. In this way the agricultural employment share reduction should slow even further, compared to the "pull" case previously described, since now also the push effect coming from non-agricultural TFP growth is not present. There indeed is a slowing down in structural transformation, both in terms of employment and output shares, which is testified by the higher dotted line in the panels of the first column. But it is

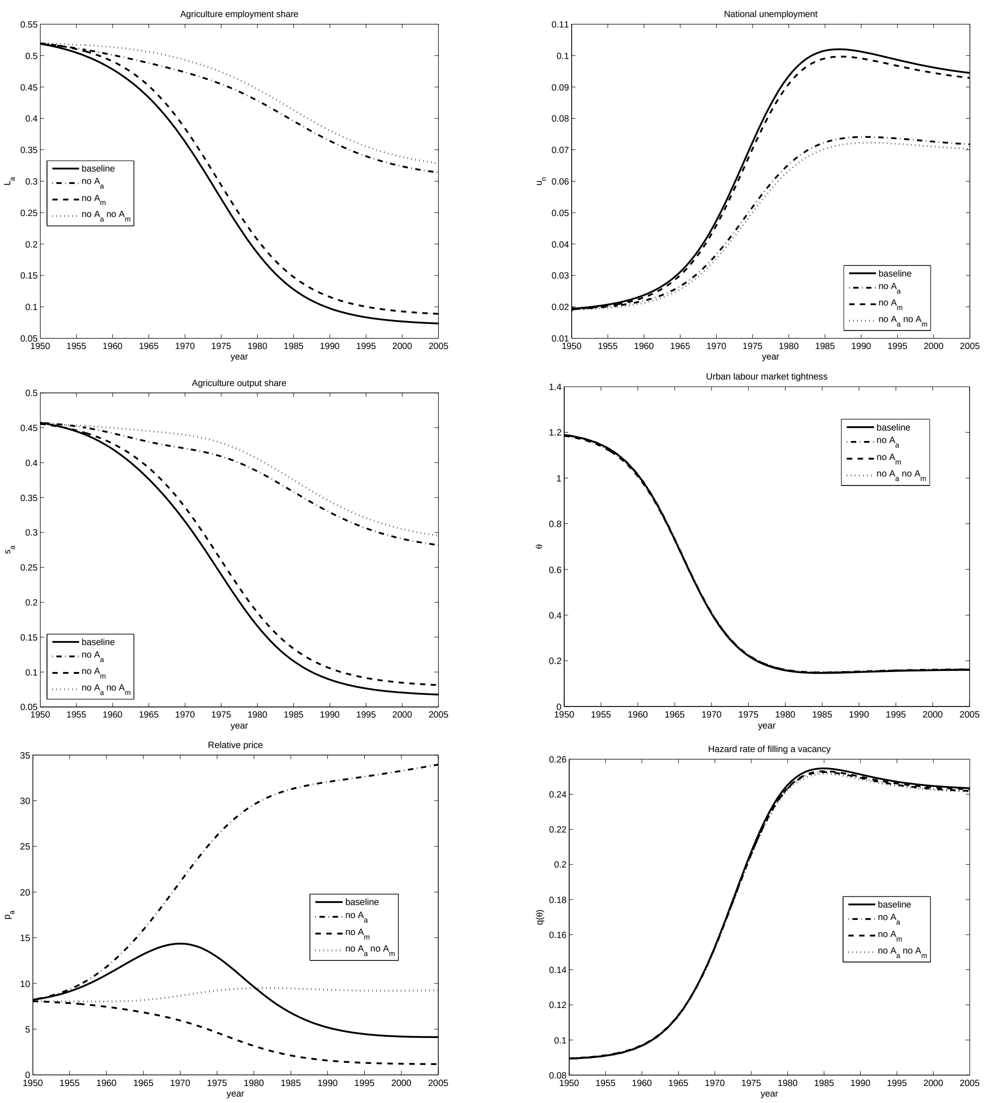

Figure 4: Counterfactuals - sectoral TFP growth

very small and the dotted line is actually quite close to that representing the "switch off A_a" case. The relative price of the agricultural good is again consistent with the assumed behaviour of productivities, since it displays a roughly constant path along all the transition, thus mirroring the absence of change in both A_a and A_m. Finally, the small reduction in the size of the non-agricultural sector is translated into a slightly lower unemployment rate.

Overall, what the counterfactual simulations described above seem to suggest is that the greatest impact on structural transformation is given by TFP growth in agriculture and capital deepening, while TFP growth in the non-agricultural sector seems to play a minor role, probably because the size of the increase in non-agricultural TFP is more modest than for agriculture in the baseline scenario. Furthermore, the behaviour of the relative price in this setup, although representative of the behaviour of sectoral productivities, cannot be used to infer the relative importance of one or the other for structural transformation, as capital deepening influences reallocation. Finally, different dynamics of sectoral TFP impact on the labour market only through the relative size of the two sectors, which affects unemployment. But to find an effect also on other variables like labour market tightness or the average duration of a vacancy, we need to look at changes in labour institutions, a task which is undertaken in the following section.

5.2.3. Changes in institutions

The second set of counterfactual experiments regards the effect of changes in labour institutions on the overall structural transformation in Spain. In particular, I run three different experiments. First, I ask how structural change would have been affected had worker bargaining power remained at the low level of the dictatorship. In this case, firms, would find it profitable to open more vacancies in the non-agricultural sector, thus making migration more attractive to workers. On the other hand, however, lower bargaining power makes seeking employment in the city less attractive to workers because they gain a lower share of the match surplus. Thus we would expect an ambiguous effect on structural transformation. Second, I ask how structural change would be affected had recruiting costs remained as high as at the beginning of the transition. If that was the case, structural change should be weakened, as firms would find it more costly to keep a vacancy open, inducing them to recruit fewer workers. Finally, the third counterfactual experiment investigates the combined effect of the previous two hypotheses.[37]

All results are summarized in the panels of figure 5, where, as reference, the behaviour of the corresponding variable in the baseline calibration is also shown. As in the previous section, results for structural transformation are displayed in the first column of figure 5, while the second column looks at the key labour market variables in more detail.

Starting from the first experiment, I run a simulation in which I "switch off" the exogenous change in workers' bargaining power, keeping it fixed at its assumed initial level (0.1 in 1950). As is evident from the path of the dash-dotted line in the first panel of the first column, there is virtually no difference in terms of structural change from the baseline case. This is also confirmed even if we look at the path of the agriculture output share, or that of the relative price (second and third panel of first column).

However, differences do arise when looking in more detail at the non-agricultural labour market, where the effect of lower bargaining power becomes evident (again, dash-dotted line, but now in the panels of the second column). In particular, as suggested earlier, firms open more vacancies because

[37] As already noted for the first set of counterfactual experiments, also in this case all remaining parameters which are not subject of the experiments are treated in the same way as in the baseline case. See the discussion at the beginning of the previous section for details.

they envisage more gains from matching. Indeed, labour market tightness exhibits a non-monotonic path: in the first 20 years it decreases as a consequence of the progressive attraction of workers to the non-agricultural sector, in response to the initially higher non-agricultural TFP growth.

In the second part of the period, however, as agriculture's TFP growth outweighs that of non-agriculture and the "push" effect kicks in, migration continues to happen, but it is absorbed by the increased number of vacancies arising from the reduction in entry costs, an effect fostered also by the fact that worker bargaining power remains at the (low) initial level. This eventually translates into a small reduction in unemployment during the second half of the 1970s, making labour market tightness increase in the corresponding period and therefore yielding a non-monotonic path for θ. [38]

This effect is not present in the baseline model because the contemporaneous increase in worker bargaining power keeps firms from opening additional vacancies. A further confirmation of the above mechanism is given by the increased average duration of a vacancy, which is the inverse of the hazard rate of filling a vacancy, depicted in the bottom right panel of figure 5.

Overall, keeping bargaining power at its initial level translates into a greater absorption of unemployed in the long run, but virtually no effect is detectable in terms of structural change. More precisely, the two opposite effects at work mentioned earlier offset each other almost completely, resulting in a negligible effect on structural transformation: on the one hand, the mechanism working through firms leads to a greater reduction in the agriculture employment share; on the other hand, there is the more direct effect of bargaining power on workers' willingness to migrate. From migration condition (31), a weaker bargaining power means a lower expected wage in the non-agricultural sector (lower lifetime utility of being unemployed), thus a reduction in workers' incentive to migrate and an overall path of agricultural employment by and large similar to the baseline case.

Roughly the same argument in reverse can be made for the second counterfactual experiment, in which I "switch off" the exogenous change in the flow cost of posting a vacancy (the dashed line in figure 5). In this case, the expected weakening effect on structural change of high recruiting costs throughout all the period is offset by an equal strengthening effect operating through the increase in the expected lifetime utility of being unemployed. On the one hand, it is true that firms are less willing to open vacancies because of increased costs; on the other hand, if the vacancy was already open and a match was formed, they would save a higher amount of hiring costs. As inspection of equations (31) and (63) makes clear, part of these savings go to workers in the form of higher non-agricultural wages, thus increasing their expectation of future earnings in the city and their incentives to migrate.[39] Again, because of these two counterbalancing forces, the overall net effect on structural transformation

[38] This mechanism is present also in Satchi and Temple (2009), where, since vacancy opening costs are assumed to be invariant over time, a reduction in workers' bargaining power actually translates into a smaller size of the informal sector (the counterpart of unemployment here). Moreover, also in their case, reducing β does not seem to have an important effect on the relative size of the agricultural and non-agricultural sectors.

[39] In the words of Pissarides (2000): "Workers are rewarded for the saving of hiring costs that the representative firm enjoys when a job is formed".

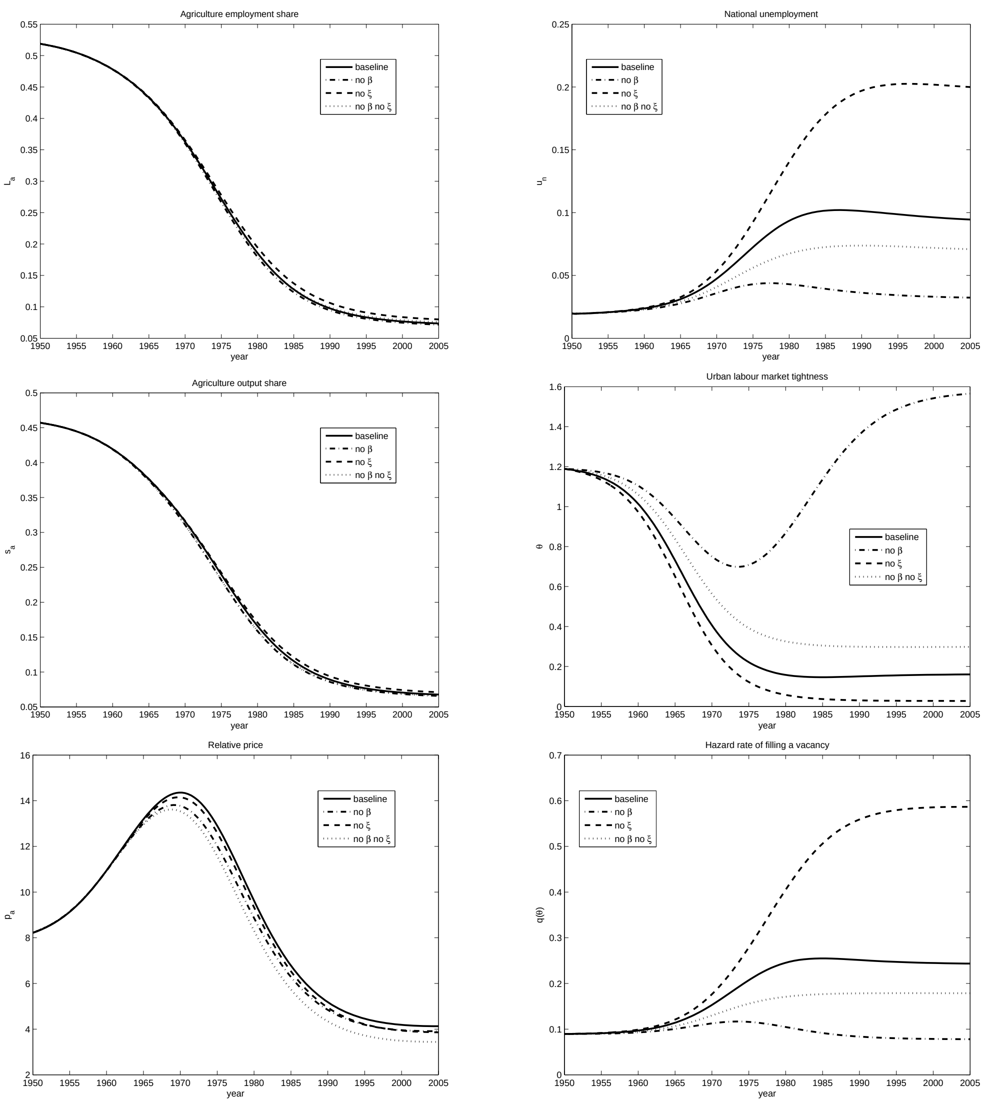

Figure 5: Counterfactuals - labour institutions

is negligible (the dashed lines in the first column of figure 5 are hardly distinguishable from the solid ones), but some effect is indeed apparent within the non-agricultural labour market: although firms open fewer vacancies, workers keep on migrating, thus enlarging the unemployment pool also in the long run (top right panel in figure 5); labour market tightness reduces quite substantially, and so does the average duration of a vacancy, since for any given vacancy there is a greater number of unemployed workers available (middle and bottom right panels).

Finally, a third counterfactual experiment studies the model when relevant labour market institutions (β and ξ) are left at their initial levels when Franco's regime was still in power. In other words, I combine the two experiments above, "switching off" the exogenous change in both worker bargaining power and firm entry costs. Results yield paths between the two extremes previously discussed (the dotted line in figure 5). Although there is still no effect on structural transformation, given the combined offsetting effects on worker and firm behaviour, the non-agricultural labour market is characterized by a consistently lower path of unemployment than in the previous experiment where I "switched off" growth in ξ, but not in β. This is because some of the unemployment is absorbed by the additional vacancies opened in response to a now lower worker bargaining power. Consequently, labour market tightness and vacancy duration paths are in between the respective ones in the first two experiments.

Overall, the main message from the counterfactual experiments of this section is that the change in labour market institutions did not affect the process of structural transformation, which still seems to be driven by changes in sectoral productivities, in particular in agriculture. However, they obviously affected the non-agricultural labour market, influencing its ability to absorb the release of labour from agriculture, and therefore the level of unemployment.

6. Growth accounting with search frictions

In this section I offer an application of the growth accounting decomposition proposed previously, where the existence of search frictions in the labour market is taken into account. As specified earlier, the Solow residual is accounted for by the contribution of sectoral technology growth, labour reallocation, and an adjustment for search frictions as described in section 4. reported here for convenience:

$$\frac{\dot{TFP}}{TFP} = (1-s_a)\frac{\dot{A_m}}{A_m} + s_a\frac{\dot{A_a}}{A_a} \tag{65}$$

$$+B_1\frac{\dot{m_e}}{m_e} \tag{66}$$

$$+s_\pi\frac{\dot{A_m}}{A_m} - s_\pi\frac{\dot{\Pi}}{\Pi}. \tag{67}$$

Applying this decomposition to the model in its baseline case yields the results depicted in figure 6, where each component's contribution is given in percentages of the Solow residual. As in the simulation, the transition has been induced by increases in sectoral TFP, it is not surprising that the main role is played by the growth in A_a and A_m. In particular, non-agricultural TFP is what matters in the first two decades where the "pull" effect is at work, while in the remaining part most of the growth is accounted for by agricultural productivity gains, and search frictions. Labour reallocation accounts at most for 2 percent of the Solow residual in the early 1980s, the period of faster structural change in the simulated baseline model. The main explanation of the negligible growth bonus given by reallocation lies in the fact that this decomposition is based on the differential in wages rather than marginal products. The calibrated model generates low values of the wage differential across the two sectors which translates into very low figures for the component in (66).

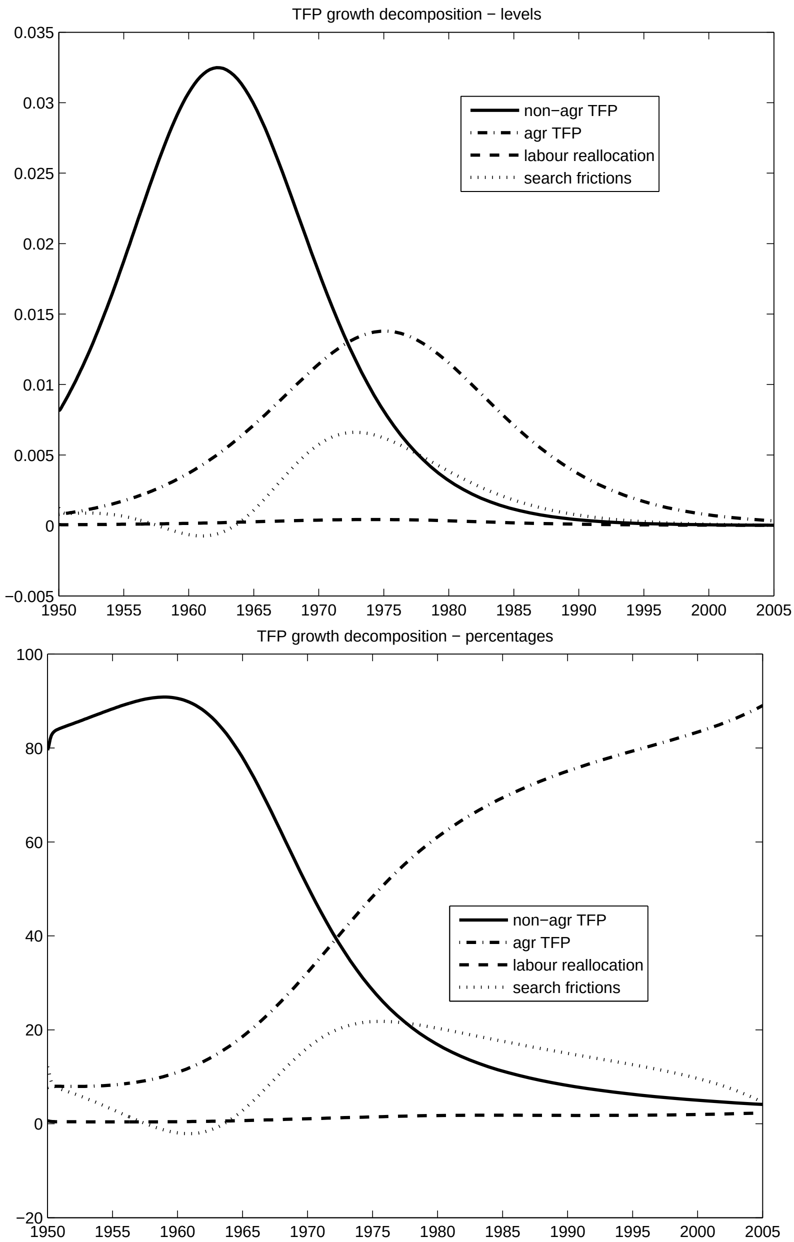

Figure 6: Growth accounting with search frictions - wage differential

This is mainly due to the fact that part of the marginal product of labour in non-agriculture has to cover the cost of opening vacancies, therefore reducing the wage differential. In fact, using the version of the decomposition in (57) - (59), which is based on the differential of marginal products across sectors, rather than wages, the contribution of the reallocation component roughly quadruples, going from the previous 2 percent of the Solow residual at peak to a more respectable 8 p.p. (figure 7), and the share of search frictions correspondingly reduces. This version of the decomposition, although less useful when needed to be used in the context of empirical estimation, is more informative on the real growth bonus given by the flows of workers between sectors. As further confirmation of the argument above, the marginal product of labour instead is found to be 35 percent higher in non-agriculture than in agriculture at the beginning of the transition, and in the steady state it is still at least 5 percent higher.

7. Conclusion

This paper aims to introduce a framework for studying structural change with matching frictions, including the growth accounting decompositions that arise in this type of model. In this sense it gives a twofold contribution: on the one hand, it provides a quantitative evaluation of the effects of sectoral TFP increases, trying to disentangle their relative importance for overall structural change. On the other, it looks in detail at the interactions with the labour market, analyzing the general equilibrium effects of changes in labour market institutions.

The model proposed is a dynamic model of a dual economy, where agriculture is assumed to be perfectly competitive, while non-agriculture is characterized by the presence of search frictions. The quantitative analysis of a transition has been undertaken calibrating the model to the Spanish postwar experience, and its transition from dictatorship to democracy (which characterized the first half of the reference period) has been captured with an exogenous change of parameters in the search model of the labour market, (increasing) worker bargaining power and (decreasing) firm entry costs. Transition has been induced by imposing an exogenous change in sectoral TFPs, whose dynamic path is consistent with those estimated from available data. Furthermore, using a growth accounting exercise, the different components of overall TFP growth have been highlighted and quantified: pure technology growth and the reallocation of labour between sectors, including an adjustment due to the presence of search frictions in the labour market.

In a series of counterfactual experiments I address the relative importance of sectoral productivity growth and changes in labour market institutions for structural transformation. Main results point toward a greater importance of productivity improvements in agriculture (the "push" effect) rather than in non-agriculture, since the extent of structural transformation is affected the most in the former case, while in the latter structural change appears to be mainly driven by capital accumulation rather than TFP growth. Changes in labour market institutions turn out to affect mainly the level of unemployment but are found to have only a modest effect on the pattern of structural transformation. Overall, labour reallocation with search frictions seems to account for roughly half of the initial increase in Spanish unemployment.

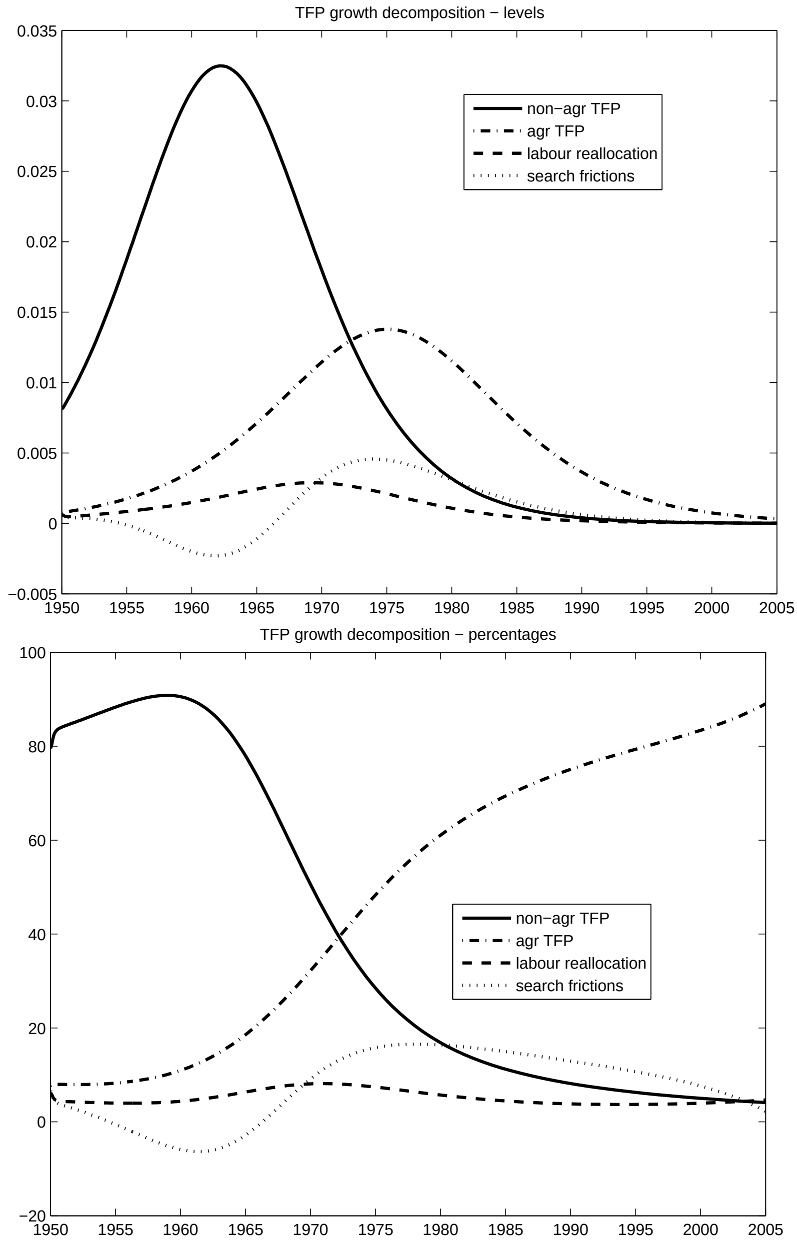

Figure 7: Growth accounting with search frictions - marginal product differential

Of course, given the multiplicity of the forces in place, the model had to be simplified along several dimensions, resulting in a few limitations in the results. For example, accounting for heterogeneities in levels of human capital across sectors, as advocated by Buera and Kaboski (2009), might help in improving the model performance in terms of matching the overall GDP growth rate; while a more detailed description of the labour market, taking into account, along the lines of Bentolila et al.

(2010), the massive adoption of temporary contracts, as a distinctive feature of the Spanish labour market since the introduction of democracy, might be able to explain the remaining part of the increase in unemployment since the late 1970s. I leave these efforts to future research.

Nonetheless, the model is already useful for the interpretation of historical structural transformation experiences, either those already concluded, as the one adopted here as a case study, or those still unfolding in developing countries like Brazil, China and India. For example, Bosworth and Collins (2008) find that agriculture TFP growth has played a major role in China's economic growth and structural transformation, a result confirmed also by Dekle and Vandenbroucke (2012), who also quantify the role of government for structural transformation.

8. Appendix

8.1. Sectoral TFPs

Figure 1 in the text provides the time paths for sectoral TFPs as derived from EU-KLEMS data. Their striking feature is the much larger TFP increase registered in agriculture, in particular in the second half of the century, with respect to the relevant increase in non-agriculture. This relative behaviour has some obvious consequences for the transitional dynamics of the model, making structural transformation mainly driven by productivity improvements in agriculture and capital accumulation in non-agriculture. However, although the emerging pattern revealed looks like a puzzle, in particular with respect to the obvious increase in Spanish labour productivity in the second half of the century, this is a direct consequence of the data and studies on sectoral TFP growth in Spain conclude in the same direction.

With respect to data manipulation, sectoral TFPs time series were derived performing a standard growth accounting exercise, as the Solow residual resulting from the difference between sectoral value added growth and growth in factor inputs (weighted by their respective shares in sectoral value added). EU-KLEMS directly provides figures for sectoral TFP growth, but they have not been used directly in the simulation because of the different level of aggregation required: for the purpose of the paper I needed figures for the market economy non-agricultural sector, while EU-KLEMS data are at a more disaggregated industry-level. Therefore non-agriculture TFP growth was derived as the weighted sum of non-agriculture single industries TFP growth. For comparison, the figure below provides the TFP paths for agriculture, manufacturing (the main industry in non-agriculture) and the overall economy using both my own calculations and the direct EU-KLEMS figures: it can be noted that the difference between the two series is negligible.

The time pattern of sectoral TFPs in Spain is also confirmed by studies on sectoral TFP growth in Spain, which, using different sets of data, still find rapid TFP growth in agriculture and slow (if not negative) TFP growth in non-agriculture. As an example, Martín-Retortillo and Pinilla (2015) document that Spanish agriculture TFP growth was amongst the highest in Europe between 1950

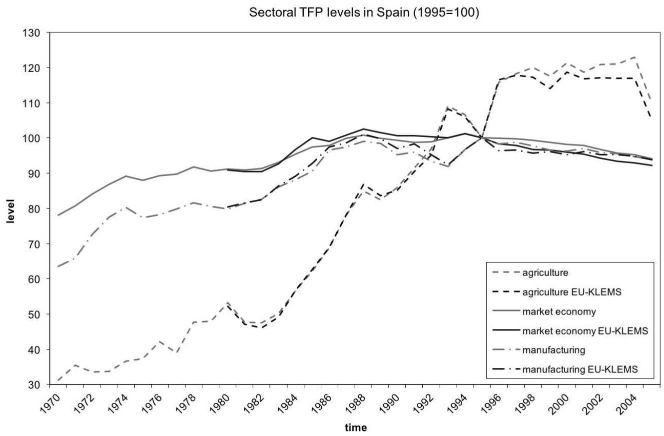

Figure 8: Sectoral TFP levels vs EU-KLEMS data

and 2005, with average annual growth rate of 1.93%, while Mas and Quesada (2005) find negative contribution to productivity growth during the period 1985-2004 for market non-agriculture. Overall, Prados de la Escosura and Rosés (2009) (and the other studies surveyed in their paper) find that fastest TFP growth in Spain was recorded between 1950 and 1974 (with average annual growth rate of 3.7%), just the same period when fastest sectoral growth is registered, as reported in figure 1.

Thus, although the emerging pattern revealed might look like a puzzle, it clearly emerges from the data and is in accordance with the available literature for sectoral TFP growth in Spain.

8.2. Extensions

The model proposed in this paper could be extended in many ways, in order to make it a more accurate description of reality (see the discussion in the main text about the role of temporary and part-time jobs in the non-agricultural labour market in Spain), or to study other possible effects of certain features of the economy on the process of structural transformation. In what follows I propose two straightforward extensions.

8.2.1. Increasing returns to scale

The first possible extension to the model would be the introduction of increasing returns to scale in the non-agricultural sector. Following an argument dating back to Kaldor (1966) and recently formalized by Graham and Temple (2006) in the context of dual economy models, this assumption may impact on structural change making it faster, as it would increase incentives for migration in response to the further higher wages (other things equal) that could be guaranteed in the non-agricultural sector when it enjoys economies of scale. Thus, the main modification to the model is related to the form of the production function in non-agriculture, which, following Graham and Temple (2006), is assumed to be dependent on labour and capital, but also on an externality captured by the overall size of the sector, on the same lines of the assumptions in variable returns to scale models:

$$Y_{mj} = A_m K_{mj}^{\mu} (L_{mj})^{1-\mu} Y_m^{\frac{\phi}{1+\phi}} \tag{68}$$

where the $j-th$ firm's level of output is denoted by Y_{mj}, with capital K_{mj} (with elasticity μ), and labour employed L_{mj}, while A_m and Y_m are the overall non-agriculture TFP and output respectively and $\phi \geqslant 0$ captures the extent of increasing returns. Aggregating over all firms yields the non-agricultural sector production function as:

$$Y_m = [A_m K_m^{\mu} (L_m)^{1-\mu}]^{1+\phi} \tag{69}$$

where now all variables are dependent also on the extra parameter ϕ, which, if different from zero, captures the extent of the returns to scale present in the non-agricultural sector. Otherwise, (69) would return to the standard form in (13).

The analysis then proceeds as in the main text, using the new production function specified above, which yields the same system of equation as in (32)-(47), with the only exception that now the equation defining the non-agricultural production function will be (69).

8.2.2. Efficiency units of labour

Another simple extension to the model would be to introduce time variation in the endowment of labour, reflecting exogenous changes in hours worked and in educational attainment. In this way, it would also be possible to capture variations over time in human capital or labour intensity. In particular, each worker in either sector could be thought to provide h efficiency units of labour, which are assumed to depend on the combined contribution of average working hours h_w and human capital h_h. However, in this extension no heterogeneity across sectors is assumed along this dimension. Again, as in the previous section, the new additional assumption would be reflected in a slightly different expression of the production function (now in both sectors), that would read as follows:

$$Y_a = A_a[\alpha R^{-\rho} + (1-\alpha)(hL_a)^{-\rho}]^{-1/\rho} \tag{70}$$
$$Y_m = [A_m K_m^{\mu} (hL_m)^{1-\mu}]^{1+\phi} \tag{71}$$

where $h = h_h h_w$, is the amount of efficiency units provided by workers and in the second equation I used the more general form in (69).

In this modified setup, the extra parameter h will obviously appear in all the equations related to the marginal product of labour, which now is not per capita, but per efficiency units:

$$
\begin{aligned}
w_a &= p_a(1-\alpha)A_a^{-\rho}\left(\frac{Y_a}{hL_a}\right)^{1+\rho} && (72)\\
y_{mj} &= (1-\mu)\frac{Y_{mj}}{hL_{mj}} && (73)
\end{aligned}
$$

This modification would also be reflected more generally in the equations describing the non-agricultural labour market, as now each worker is paid the per efficiency unit wage w_m times the amount of efficiency units h provided. Thus, the system summarizing the dynamics of the model would read as follows:

$$
\begin{aligned}
\dot{K_m} &= s(\Upsilon_m + p_aY_a) - \delta K_m && (74)\\
\dot{L_m} &= \theta q(\theta)(L_c - L_m) - \lambda L_m && (75)\\
(r+\lambda)J &= h(1-\beta)(y_m - \eta w_m) - \beta\xi h w_m\theta + \dot{J} && (76)\\
J &= \frac{\xi h w_m}{q(\theta)} && (77)\\
w_m &= (1-\beta)\eta w_m + \beta(y_m + \xi w_m\theta) && (78)\\
w_a &= \eta w_m + \frac{\beta}{1-\beta}\xi w_m\theta && (79)\\
r+\delta &= \mu\frac{Y_m}{K_m} && (80)\\
y_m &= (1-\mu)\frac{Y_m}{hL_m} && (81)\\
w_a &= p_a(1-\alpha)A_a^{-\rho}\left(\frac{Y_a}{hL_a}\right)^{1+\rho} && (82)\\
r_a &= p_a\alpha A_a^{-\rho}Y_a^{1+\rho} && (83)\\
\frac{\lambda_p}{1-\lambda_p} &= \frac{(1-s)\Upsilon_m - sp_aY_a + \gamma_m}{p_a(Y_a-\gamma_a)} && (84)\\
& && (85)
\end{aligned}
$$

where:

$$
\begin{aligned}
q(\theta) &= M_p\theta^{-\gamma} && (86)\\
p_aY_a &= w_aL_a + r_a && (87)\\
\Upsilon_m &= w_mL_m + (r+\delta)K_m && (88)
\end{aligned}
$$

As for the calibration reported in the main text, in principle modifications over time in hours worked and/or the endowment of human capital could be accounted for by adoption of another law of motion of the same type as in (60). However, using data from Leandro Prados de la Escosura on hours worked for Spain, I find a decline in hours per worker of around 27% over the period 1950-2000. Using data on educational attainment from de la Fuente et al. (2003), and translating these into effective units of labour using the approach of Bils and Klenow (2000), I find an increase of 31% in labour quality over 1960-2000. (This is based on the de la Fuente estimate of the return to schooling of 8.4% and an increase in average years of schooling from 4.97 in 1960 to 8.19 in 2000.) Hence these changes - the decrease in average hours and the increase in labour quality - offset each other almost perfectly. Thus, for simplicity, our calibration ignores both, and treats workers as supplying a fixed quantity of labour, which is normalized to 1 in the model in the main text.

8.3. Growth accounting full model

In what follows it will be shown how the decomposition of total TFP growth has been derived for the case of a closed economy with search frictions in the labour market, in the case of the full extended version of the model presented above, i.e., allowing for both the presence of increasing returns to scale and changes in efficiency units of labour. It is straightforward to derive the version presented in section 4. just by applying the relevant simplifications: $\phi = 0$ and $h = 1$.

The starting point is equation (53), decomposing total real value added growth as the difference between growth in total output and the part "absorbed" in the recruiting process (everything net of the evolution in the price level), which is reported here for convenience:

$$\frac{\dot{\Upsilon_{real}}}{\Upsilon_{real}} \equiv \frac{\dot{Y}}{Y}\frac{Y}{\Upsilon} - s_{\pi}\frac{\dot{\Pi}}{\Pi} - s_{\pi}\frac{\dot{L_m}}{L_m} - s_a\frac{\dot{p_a}}{p_a}. \tag{89}$$

The strategy consists in two main steps: first, deriving a decomposition of the first term on the right hand side, which is nothing else than total *gross* output growth, weighted by its share in total value added; second, combining the expression thus obtained with the other three terms on the right hand side netting out measurable growth in factor inputs.

In the first step, the decomposition goes roughly on the same lines as that provided in Temple (2001), as modified in Monteforte (2011) where a version dealing with the presence of increasing returns and unemployment arising from efficiency wages is proposed. In this case however, there are also search frictions and the relative price is not fixed at the world level.

Starting from agriculture, nominal output ($p_a Y_a$), weighted by its share in total value added ($s_a \equiv \frac{p_a Y_a}{\Upsilon}$), can be decomposed as:

$$\frac{p_a Y_a}{\Upsilon}\frac{(p_a \dot{Y}_a)}{p_a Y_a} = s_a\frac{\dot{Y_a}}{Y_a} + s_a\frac{\dot{p_a}}{p_a} \tag{90}$$

$$= s_a\frac{\dot{A_a}}{A_a} + \frac{w_a hL}{\Upsilon}\frac{(h\dot{L}_a)}{hL} + \nu\frac{\dot{R}}{R} + s_a\frac{\dot{p_a}}{p_a} \tag{91}$$

where the second line follows from the use of the agricultural production function (10), and the equality between factor prices and marginal products, with $\nu \equiv r_a R/\Upsilon$ denoting the share of land income in total income of the economy.

Similarly, nominal *gross* output in non-agriculture, again weighted by its share in total value added ($Y_m/\Upsilon = 1 - s_a + s_\pi$), can be decomposed as follows:

$$\frac{Y_m}{\Upsilon}\frac{\dot{Y_m}}{Y_m} = (1+\phi)(1-s_a+s_\pi)\frac{\dot{A_m}}{A_m} + (1+\phi)(1-\omega-\nu)\frac{\dot{K_m}}{K_m} + (1+\phi)\frac{y_m hL}{\Upsilon}\frac{(h\dot{L}_m)}{hL_m} \quad (92)$$

$$= (1+\phi)(1-s_a+s_\pi)\frac{\dot{A_m}}{A_m} + (1+\phi)(1-\omega-\nu)\frac{\dot{K_m}}{K_m} \quad (93)$$

$$+(1+\phi)\frac{w_m hL}{\Upsilon}\frac{(h\dot{L}_m)}{hL} + (1+\phi)s_\pi\frac{\dot{L_m}}{L_m} \quad (94)$$

where the first line makes use of the relevant production function, and the second line exploits the relation between non-agricultural wage and marginal product of labour expressed in equation (49). As standard, factor inputs are weighted by the shares of their respective income in total value added, with in particular $\omega \equiv (w_a hL_a + w_m hL_m)/\Upsilon$ denoting the labour share and consequently $(1-\omega-\nu) = (r+\delta)K_m/\Upsilon$ the capital share.

Aggregating over sectors yields:

$$\frac{Y}{\Upsilon}\frac{\dot{Y}}{Y} = (1-s_a+s_\pi)\frac{\dot{Y_m}}{Y_m} + s_a\frac{(p_a\dot{Y}_a)}{p_aY_a} \quad (95)$$

$$= (1+\phi)(1-s_a+s_\pi)\frac{\dot{A_m}}{A_m} + s_a\frac{\dot{A_a}}{A_a} \quad (96)$$

$$+(1+\phi)(1-\omega-\nu)\frac{\dot{K_m}}{K_m} + \nu\frac{\dot{R}}{R} + s_a\frac{\dot{p_a}}{p_a} \quad (97)$$

$$+(1+\phi)s_\pi\frac{\dot{L_m}}{L_m} + (1+\phi)\frac{w_m hL}{\Upsilon}\frac{(h\dot{L}_m)}{hL} + \frac{w_a hL}{\Upsilon}\frac{(h\dot{L}_a)}{hL} \quad (98)$$

The last two terms in the expression above can be rewritten as:

$$\omega\frac{(h\dot{L}_e)}{hL_e} + \varphi(d-1)(1-a-u_n)\left[\frac{\dot{L_m}}{L_m} - \frac{\dot{L_e}}{L_e}\right] + \phi d\varphi(1-a-u_n)\frac{(h\dot{L}_m)}{hL_m}$$

where $a \equiv \frac{L_a}{L}$ is the agriculture employment share, $u_n \equiv \frac{(L-L_a-L_m)}{L}$ is the economy wide unemployment rate, $L_e \equiv L_a + L_m$ is total employment, $d \equiv w_m/w_a$ is the wage differential, and $\varphi \equiv \frac{w_a hL}{\Upsilon}$ is a parameter roughly equal to the share of agriculture labour income in total value added.

Noting that the term in square brackets above is the growth rate of the share of non-agriculture employment in total employment, and denoting it by $m_e \equiv L_m/L_e$, the final decomposition of total nominal output growth results in:

$$
\begin{aligned}
\frac{Y}{\Upsilon}\frac{Y}{Y} \quad = \quad & (1+\phi)(1-s_a+s_\pi)\frac{\dot{A_m}}{A_m} + s_a\frac{\dot{A_a}}{A_a} \\
& +(1+\phi)(1-\omega-\nu)\frac{\dot{K_m}}{K_m} + \nu\frac{\dot{R}}{R} + \omega\left(\frac{\dot{L_e}}{L_e} + \frac{\dot{h}}{h}\right) \\
& +\varphi(d-1)(1-a-u_n)\frac{\dot{m_e}}{m_e} + \phi d\varphi(1-a-u_n)\left[\frac{\dot{L_m}}{L_m} + \frac{\dot{h}}{h}\right] \\
& +(1+\phi)s_\pi\frac{\dot{L_m}}{L_m} + s_a\frac{\dot{p_a}}{p_a}
\end{aligned}
$$

The second step consists in combining the result above with the general form provided in (89). After all relevant simplifications, the final decomposition of real value added takes the following form:

$$
\frac{\dot{\Upsilon_{real}}}{\Upsilon_{real}} \quad = \quad (1-\omega-\nu)\frac{\dot{K_m}}{K_m} + \nu\frac{\dot{R}}{R} + \omega\left(\frac{\dot{L_e}}{L_e} + \frac{\dot{h}}{h}\right) \tag{99}
$$

$$
+(1+\phi)(1-s_a+s_\pi)\frac{\dot{A_m}}{A_m} + s_a\frac{\dot{A_a}}{A_a} \tag{100}
$$

$$
+\varphi(d-1)(1-a-u_n)\frac{\dot{m_e}}{m_e} \tag{101}
$$

$$
+\phi(1-\omega-\nu)\frac{\dot{K_m}}{K_m} + \phi s_\pi\frac{\dot{L_m}}{L_m} \tag{102}
$$

$$
+\phi d\varphi(1-a-u_n)\left[\frac{\dot{L_m}}{L_m} + \frac{\dot{h}}{h}\right] \tag{103}
$$

$$
-s_\pi\frac{\dot{\Pi}}{\Pi} \tag{104}
$$

The Solow residual is typically calculated, employing readily available data, as the difference between the growth rate of output and the growth of factor inputs, which has been isolated in the first line of the above expression. Thus, the above expressions on the RHS, with the exclusion of the terms in (99), yields the decomposition of TFP growth in which I am able to disentangle the different components related to pure efficiency gains, labour reallocation, increasing returns to scale and search frictions. Finally, noting that $\omega = \varphi[a + d(1-a-u_n)]$ yields the expression given in the text.

8.4. Growth accounting using marginal product differential

In what follows I show that the decomposition of value added derived above could be rewritten using the differential of marginal products across sectors rather than the wage differential. The two terms that change from the previous case are therefore those where the wage differential is present, (101) and (103). Starting with the first, it can be noted that the marginal product differential could be rewritten as a function of the wage differential in the following way:

$$d_{mpl} = \frac{y_m}{w_a} = \frac{dy_m}{w_m} \tag{105}$$

where y_m denotes the marginal product of labour in non-agriculture, and I use the agriculture wage w_a given perfect competition in that sector. Substituting in the above expression and combining with (49) and the definition of φ, it is easy to show that (101) can be rewritten as:

$$[\varphi(d_{mpl} - 1)(1 - a - u_n) - s_\pi]\frac{\dot{m}_e}{m_e} \tag{106}$$

On the other hand when dealing with the marginal product differential it is also true that:

$$\omega + s_\pi = \varphi[a + d_{mpl}(1 - a - u_n)] \tag{107}$$

substituting in for φ and doing all the relevant simplifications yields the expression given in the text. Exactly the same argument applies when rewriting (103) in terms of the marginal product differential.

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