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WHEN LESS IS MORE: OVERCAPACITY AND LABOUR MARKET RIGIDITY

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ACRONYMS

CU Capacity utilization

EPL Employment Protection Legislation

FRB Federal Reserve Bank

KS Kreps and Scheinkman (1983)

RBC Real Business Cycles

TFP Total Factor Productivity

OVERCAPACITY AND LABOUR MARKET RIGIDITY

1 INTRODUCTION

Business cycles and demand volatility prevent demand and supply from being perfectly matched, and the existence of output gaps implies the partial dissatisfaction of either consumers or producers. More worryingly, persistent negative output gaps reveal a systematic excess of physical capacity. After the 2009 financial and economic turmoil, the issue of overcapacity turned out to be a priority in the policy agenda, especially in those countries where demand and consumptions failed to recover.

The first contributions to the comprehension of excess capacity date back to the late 1970s, when available techniques and models failed to explain the counter-cyclical behavior of capacity utilization, CU, following the rise in energy prices. At the same time, the Industrial Organization literature suggested two main explanations for the rise of excess capacity. Overcapacity can arise as a result of strategic interaction (as an excessive output commitment results of Spence (1977) and Dixit (1979)) or as a reaction to demand uncertainty, as in Spencer and Brander (1992) and Gabszewicz and Poddar (1997). Also, models of international competition, such as Fagerberg (1988), explain that countries may choose to hold excess capacity to foster their international competitiveness and to match increases in demand.

Although excess capacity emerges in different imperfectly competitive frameworks, the existing explanations fail to consider country or sector specific factors that firms take into account when making their capacity decisions. Throughout this thesis, we try to extend the analysis of excess capacity by looking at the impact of labour institutions. The initial hint for this analysis was provided by the dramatic excess capacity experienced by the automotive industry after the financial crises. In Detroit, the plants of the Big-3 were lining unsold vehicles, and huge parking lots, previously empty, were soon filled with cars. On the other side of the ocean, Italian, and other European, car assembly plants dramatically reduced their CU rate well below break-even. One may argue that the United States benefit from a flexible labour market, and our research question would find no fertile ground. Nonetheless, the Big-3, at that time, were forced to deal with a giant trade union, the United Auto Workers, which was able to negotiate not only unsustainable hourly wages, but also extremely costly regulations in case of lay-offs and dismissal. On the other side, Italy has always been characterized by a relatively rigid labour market, with fragmented unions and troublesome collective negotiations.

Although these examples refer to a very specific sector, during a particular economic cycle, they made us wonder if and how the exogenous institutional background in which firms are to operate favors the rise of excess capacity. This thesis is thus an attempt to fill this gap in the literature. To this purpose, we initially review the existing contributions on physical capacity, and then we investigate the relation between overcapacity and labour market rigidity implementing a twofold approach. On the theoretical side, we adopt an ex-ante point of view and look at how labour institutions impact firms' capacity investment decisions, and observe that capacity is increasing in the rigidity of the labour market. Then, we evaluate the effect of labour protection on firms' short-tun output adjustments to assess the impact with an ex-post perspective. We observe that the protection of skilled workers tend to increase excess capacity, with the effect being more intense in capital intensive industries.

1.1 THE SURVEY

In Chapter 2, we distinguish between aggregate indicators (potential output, and output gaps) and micro-economic ones (physical capacity and CU) and we investigate their role in business cycles. We review the principal measurement techniques, and their main issues, that have been developed overtime to estimate these trend and cycle components. Then, we look at the Industrial Organization theory and review the models of imperfect competition where excess capacity emerges. As already mentioned, economic theory essentially suggests three main drivers of over capacity: strategic interaction, demand uncertainty, and increasing global competition.

In addition to the pure, and static, quantity competition games proposed in the baseline contributions by Spence (1977), Dixit (1979), Spencer and Brander (1992), Gabszewicz and Poddar (1997), we review those different settings that still involve capacity decisions and come up with excess capacity. First of all, excess capacity can also be observed in mixed oligopolies, with quantity competition taking place between a profit maximizing firm and a non-profit maximizing firm, for instance, a labour managed firm or a public one.

In their contribution, Kreps and Scheinkman (1983) embed capacity decisions in a quantity and price game, and show that this game has a unique equilibrium that corresponds exactly to the one-shot Cournot game. Despite these results, this capacity and price setting has been embedded in the analysis of collusive agreements, when firms can collude either on capacities or on prices, as in Benoit and Krishna (1985), and Davidson and Deneckere (1990). Another approach includes capacity investment decisions, and capacity adjustments, in an infinite temporal horizon, as in Abel (1981) and Besanko et al. (2010).

We conclude this Chapter recalling the importance of finding alternative explanations for excess capacity, and stressing the need to look also at the consequences of overcapacity, not only in aggregate terms, but fore and foremost also with a local perspective.

1.2 THE THEORETICAL PAPER

In chapter 3, we set up a two-stage quantity competition game between two firms located in two different countries. Firms initially install physical capacity, according to their expectations over final demand. Once uncertainty has resolved, firms employ labour to adjust their former investment decisions so as to match final demand. Adjustments can be thus either positive or negative, depending on the direction of the shock.

We assume that second stage adjustment costs reflect the rigidity of the labour market: in the good state, when firms must produce above capacity, these costs reflect the different overtime wages firms must pay. In the bad state instead, firms cannot destroy their capacity, so they are forced to keep their plant partially idle: these adjustment costs thus reflect the different temporary lay-off costs firms must sustain.

First of all, we observe that firms install capacity only if their expectations over final demand are positive. When, in fact, the expected value of the demand additive shock is positive, firms invest in capacity to get as close as possible to the level of expected demand. In this case, we also observe that the firm incurring greater adjustment costs, and thus a more rigid labour market, is also going to install a greater level of physical capacity. This firm has in fact an additional incentive to prefer output commitment, as this firm wants to minimize the impact of future adjustment costs. If final demand is not too large, that is, if the shock is relative small in magnitude, then this firm can also benefit from a higher profitability.
If expectations over final demand are instead neutral or negative, firms do not commit and rather wait for the realization of demand before producing.

This framework thus shows that a more rigid labour market, as modeled by greater labour costs during the adjustment process, determines not only an initial greater output commitment, but also a greater excess capacity during economic downturns.

To extend our analysis, we consider two alternative cost specifications that respectively introduce a certain degree of capacity-labour complementarity and assume that firing costs, and so negative adjustments, are more costly.

1.3 THE EMPIRICAL PAPER

In Chapter 4, we estimate the impact of EPL on excess capacity. This analysis is not a structural estimate of Chapter 3, as we look at the effect of EPL on the short-run output adjustments rather than at the impact on firms' initial investment.

We exploit a country-sector panel of European manufacturing industries and proxy excess capacity with the share of physical capacity that is not used at the plant level, which is collected on a quarterly basis from the Business and Consumer Survey. In addition to this exogenous, country-specific constraint, we also include the capital intensity of the corresponding US industry, a key information that measures the irreversibility of former investment decisions.

In light of the predictions of the theoretical Chapter, and considering that capital intensive industries cannot easily adjust to demand fluctuations, we expect both the elements to contribute to the rise of excess capacity. More particularly, we estimate that an increase in the protection of regular, or skilled, workers is detrimental to the CU rate, and ultimately contribute to the generation of excess capacity. We also find a robust evidence that the effect of EPL is stronger, in terms of excess capacity, in capital intensive industries.

As a robustness check, we perform a diff-in-diff analysis and observe that countries experiencing an increase in EPL overtime also tend to experience greater overcapacity.

2

A SURVEY ON PHYSICAL CAPACITY

Abstract

Although the first contributions on overcapacity date back to the 1970s, the recent economic and financial crises revealed how exposed industries are, in terms of excess capacity, to demand volatility and uncertainty, and persistent negative output gaps suggest that the comprehension of excess capacity is far from being complete.

This work reviews the main definitions of potential output, output gaps, and CU, and surveys the available measurement techniques, both empirical and theoretical. This paper also surveys the existing explanations for excess capacity suggested by the theoretical literature (strategic interaction, demand uncertainty, and international competitiveness), and stresses the importance of finding alternative explanations for overcapacity, accounting, for instance, for the institutional background in which firms are to operate.

Keywords: Macroeconomic Aspects of International Trade and Finance, Industrial organization.

JEL Classification: F4, L.

2.1 INTRODUCTION

Physical capacity, or production capacity, indicates the maximum output that can be attained by a single unit of analysis, from a single plant up to an entire country, in a given time framework. Hence, the fate of potential output, in terms of creation and destruction, of accumulation and dismantling, reveals the long-run economic trend, and accounts for firms' investment decisions and for the soundness of the economic system as a whole. Deviations of actual production from this measure of potential output are instead business cycle adjustments, that link the real and monetary sides. As such, output gaps are constantly and carefully monitored by monetary and fiscal institutions.

These indicators gained considerable attention in the economic research agenda at the end of the 1970s, when theoretical works successfully modeled firms' capacity investment decisions and when the first measurement techniques were developed. Nonetheless, the 2009 financial global crises revealed, in a dramatically intensive way, how vulnerable the industrial sector is to financial volatility and to demand shocks. The credit crunch that followed the mortgage crises soon spread to the industrial side: before 2009, firms were, generally speaking, operating at full capacity. After 2009, when the financial crises impacted the real side of the economy, final consumption levels dropped and most firms experienced excess capacity, with severe repercussions on employment levels, inflation, and social stability. All these elements suggest that economic research on excess capacity is far from being over. New theoretical models are needed to understand why firms still commit to levels of output that are unsustainable during economic downturns, and new, updated, policy guidelines are needed to stress and encourage the adoption of a more forward thinking firm behavior. Overcapacity is unquestionably a serious concern for industrialized countries, as it entails resource waste, unemployment, land desolation, and so on. Figures 1 and 2 show how persistently negative output gaps lead to increases in unemployment levels and threaded decreases in the inflation rate, almost achieving deflation.[1]

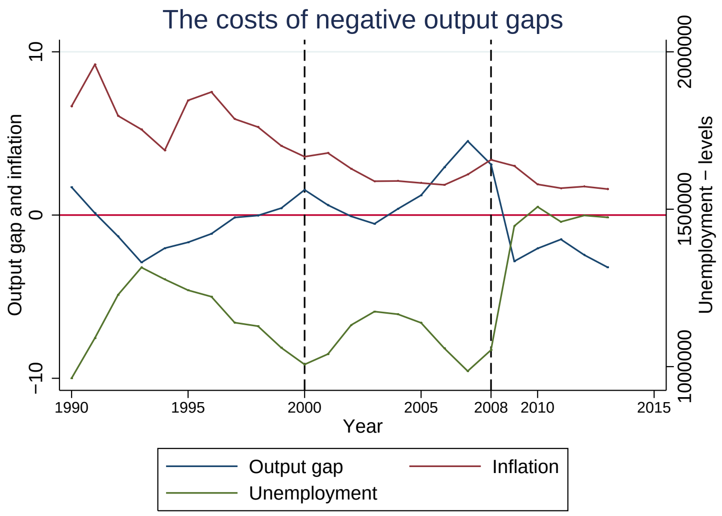


Figure 1: Negative output gaps, unemployment, and inflation

Lower CU also affects firms' profitability, as lower production volumes may impede firms to break-even. Persistently low production volumes may trigger plant closures and massive lay-offs, with consequences not only on aggregate fundamentals, but also on micro, and regional, indicators. The fate of an industry, for instance, the automotive one, can be detrimental to a whole country or even to a single city, as it happened

1 Aggregate data are collected from the OECD economic outlook. The countries included are: Australia, Austria, Belgium, Canada, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Korea, Luxembourg, Mexico, Netherlands, Norway, Poland, Portugal, Slovak Republic, Slovenia, Spain, Sweden, Switzerland, United Kingdom, United States, from 1990 to 2013.

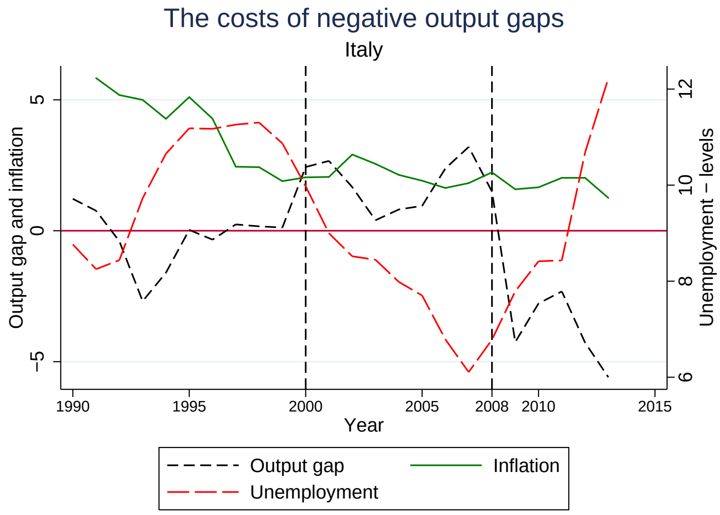


Figure 2: The Italian case

in Detroit. Figure 3 displays the House Price Index, the motor industry employment level (in thousands), and the unemployment rate for the Detroit Metropolitan area.[2] Interestingly, the excess capacity experienced by the Detroit automotive industry triggered plant closures, lay-offs, and eventually also affected housing prices:[3] during the big recession, Detroit property prices almost fell down to the 1990 levels.[4]

This work surveys the existing literature on physical and excess capacity adopting a twofold approach, to emphasize once more how theory and applied economics should move together. On one side, this work recalls the different definitions related to production capacity (potential output, output gap, index of industrial production and CU rate), as reported in Section 2.2.1. Then, it reviews the main measurement techniques, in Section 2.2.2, and it describes the role of production capacity and CU in Real Business Cycle models, Section 2.3.

The second approach focuses on the theoretical comprehension of production capacity and excess capacity, and mainly relies on the contributions to the Industrial Organization theory. Section 2.4.1 reviews the main explanations for excess capacity in models of imperfect competition, whereas Section 2.4.2 classifies the different frameworks that have been set up in the analysis of excess capacity: pure oligopolies vs. mixed duopolies, models of pure quantity competition vs. models of quantity and price competition, and static games vs. dynamic games. Last, Section 2.5 draws the main conclusion and provides some suggestions for future research.

2 Data are taken from S&P Dow Jones Indices LLC, S&P/Case-Shiller MI-Detroit Home Price Index [DEXRSA], retrieved from FRED, FRB of St. Louis https://research.stlouisfed.org/fred2/series/DEXRSA/,November24,2014.

3 The baseline year for the House Price Index is January 2000.

4 Further information on the collection of housing prices are available at http://www.spindices.com/index-family/real-estate/sp-case-shiller.

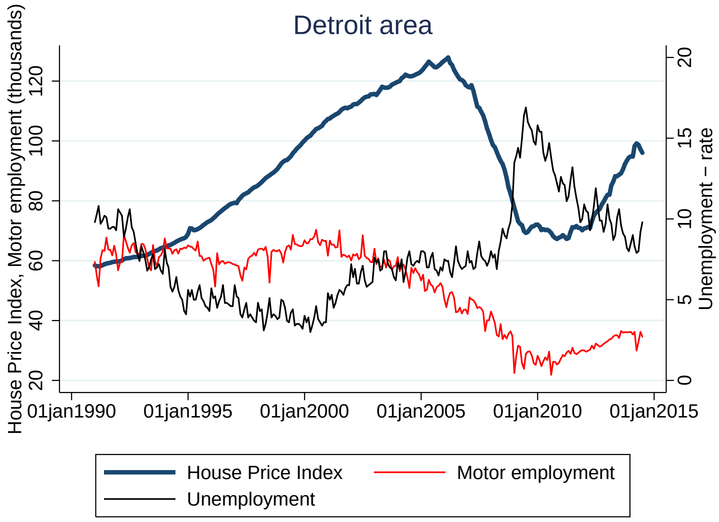


Figure 3: Detroit: House Price Index, Motor Employment and Metropolitan Area unemployment

2.2 PRODUCTION CAPACITY

2.2.1 *Definitions*

From an aggregate point of view, the monitoring and correct estimation of potential output and output gaps is necessary for the implementation of suitable monetary and fiscal policies. More specifically, *potential output*, also known as production capacity, is the "maximum amount of goods and services an economy can turn out when it is most efficient - that is, at full capacity"[5] when price pressures are absent. Hence, *output gaps*, defined as the percentage deviation of actual output from potential output, can explain inflationary trends: positive gaps reveal an excess of demand that can be compensated only with an increase in the price level. On the contrary, negative output gaps indicate an excess of supply, and prices must fall. Empirically, these two measures cannot be quantified: they can only be estimated. Measurement techniques are more thoroughly described in Section 2.2.2. Here, for sake of convenience, let's just say that observed output is made of a trend and of a cycle. Hence, filtering output from its cyclical component is the first approach to estimate potential output.[6] Alternatively, potential output can be estimated by means of a production function: for given inputs, the production function provides the maximum attainable level of output.[7]

5 As described by the International Monetary Fund (IMF), `http://www.imf.org/external/pubs/ft/fandd/2013/09/basics.htm`
6 Filtering techniques have extensively been described in Cotis et al. (2005).
7 As reported by Cotis et al. (2005), the OECD estimates potential output assuming a Cobb-Douglas production function, with Hicks-neutral technology.

The *industrial production index* allows for a better inspection of industrial dynamics. More specifically, this index is based on the output volume generated by production units: data are collected at the sector level by the OECD on a monthly basis, and are then aggregated at the country level with specific industry weights. Also, this index is classified with respect to 2010, the base year. Still, this index only provides an aggregate measure for industrial sectors, and is available at the single-digit level.[8]

CU rates are collected at a more disaggregated level, and refer to the ratio between actual output and potential, or maximum, output that could be produced by a single plant for given factor endowments and technology. Despite the plant-specific level of analysis, this measure is often aggregated at the industry level,[9] as done by the OECD and by the Federal Reserve. Surveys, though limited in nature,[10] may be a valid alternative, and are often used by economists to gain a closer look at supply dynamics. The Business and Consumer Survey (BCS) gathers production information of manufacturing firms in 27 European countries, collected by National Statistical Offices,[11] and provides a country-sector measure for the CU rate.[12]

The FRB gathers the monthly CU rate[13] of all the manufacturing, mining, electric and gas utilities production facilities located in the United States,[14] and consequently aggregates them at the industry level.[15]

2.2.2 *Measurement techniques*

This Section considers the econometric tools used to estimate potential output, output gaps, and CU. The first contributions date back to the 1980s, when the identification of proper techniques became a priority in the research agenda. Before, CU was considered as a mere pro-cyclical variable, that moved along other business cycle measures, such as labour productivity, investments, and Tobin's q. In the mid 1970s, at the onset of the energetic crises, fluctuations in CU turned out to be counter cyclical. As a consequence, researchers started devoting their

8 That is, within the industrial sector, the Industrial Production Index is reported for the Mining industry, the Manufacturing industry, and for the Electricity, gas and water industry.

9 1-Digit only.

10 As reported by the IMF, survey recipients may answer in a non-homogenous way, and the response rate may not always be satisfactory.

11 More information on the national criteria adopted are available at http://ec.europa.eu/economy_finance/db_indicators/surveys/metadata/index_en.htm.

12 Information are aggregated at the 2-digit level.

13 This rate corresponds to a seasonally adjusted output index, which is divided by a capacity index. This index quantifies the sustainability of maximum output.

14 Data are collected at the NAICS 3 or 4 -digit level.

15 Further information at available at http://www.federalreserve.gov/releases/g17/CapNotes.htm.

attention to the measurement of all the above mentioned variables in the attempt of finding an explanation for this atypical behavior.

2.2.2.1 *Potential output and output gap*

As already mentioned, potential output can be estimated by means of either a production function or output filtering techniques. Among the available filtering techniques, Cotis et al. (2005) recall:

1. Trend methods, including linear trend,[16] and split trend;[17]

2. Univariate filter methods: Hodrick Prescott filter,[18] Baxter-King filter,[19] Beveridge Nelson decomposition,[20] and Kalman filter;[21]

3. Multivariate filters: Hodrick-Prescott Multivariate,[22] Beveridge-Nelson decomposition,[23] and Kalman filter.[24]

The Production function approaches classified by Cotis et al. (2005) are:

1. Full structural model, with inputs determined endogenously from a macroeconomic model;

2. Production function with exogenous trends, with inputs determined exogenously using uni or multivariate filters;

3. Structural VAR, that estimates potential output and output gaps according to structural assumptions on economic disturbances.

Cotis et al. (2005) also review the results of these estimation techniques, and report an average 0.7/0.9 correlation index among them. Although profile estimates may be similar, these alternative methods may come up with asymmetric output gap characterizations.[25] Still, after all, these differences in the gaps amplitude are "low compared to the uncertainties surrounding their estimation". The authors also

16 Where the trend component is linear in time.
17 Trend output is calculated during each cycle, that is, between economic peaks.
18 Which introduces a trade-off between a "good fit to the actual series and the degree of smoothness of the trend series", and then filters the trend component.
19 This technique retrieves a linear trend preserving intermediate (business cycle) components, and rules out slow moving and high frequency (respectively trend and irregular) values.
20 This techniques retrieves the trend/cycle decomposition after the imposition of certain restrictions on both the elements.
21 In addition to trend cycle, this technique also includes erratic components.
22 This filter now also includes structural economic relations, such as the Phillips curve, and the Okun Law.
23 The trend is a random walk, and the stochastic component is a linear combination of innovations of GDP and other long-term GDP related variables.
24 Now taking into account also other information such as the Philips Curve.
25 For instance, in European countries HP output gaps are larger than Kalman filter output gaps.

report correlation statistics for output gap estimates and CU rates, reporting that "the HP measure of the gap is found to have a higher correlation with CU than methods based on linear trend". As far as production function techniques are concerned, Cotis et al. (2005) state that "potential output estimates (...) are somewhat more sensitive to cyclical factors (as for instance they use series of actual capital stock), but their volatility remains lower than for the majority of the statistical methods".

Despite these estimates proved to be robust and correlated, Orphanides and van Norden (2002) describe some different measurement issues that may question the reliability of output gap estimates. First of all, real time and ex-post estimates often do not coincide since output data are often revised. Then, interpretations of the business cycle are also subject to the availability of data: as new quarterly information becomes available, interpretations, or also the underlying model used to explain business cycle, may change. Aware of these measurement concerns, the authors review the estimates of the US output gap from 1960 using alternative methods to distinguish between the trend and the cycle. For each technique, they compare real-time estimates with the revisions that followed, and show that "revisions are of the same order of magnitude as the estimated output gap itself for all the methods examined". This finding confirms their initial concerns, as real time output gap estimates are not particularly reliable,[26] because end-of-sample estimates are not reliable themselves: in fact, real-time estimates would be unreliable also with the introduction of more reliable real-time data.

In a recent work, Borio et al. (2013) reject the definition of potential output as an inflation-free measure,[27] and propose an alternative estimate for potential output and output gaps that also includes the financial cycle.[28] They observe that financial cycles, as measured by credit behavior and property prices, contribute to the explanation of output cycles and can lead to a more accurate measurement of potential output. Figure 4 compares the IMF, OECD, HP ex-post and real time estimates of the US potential output with the finance-neutral measure proposed by the authors. Before the onset of the financial crises, the three real time standard measures reported a very small output gap, with output "*below, or at most close to,* potential". Only with an ex-post perspective did these measures reveal that actual output was above its potential and sustainable level. Instead, the real-time and ex-post estimates of the finance-neutral classification almost coincide, and

26 They distinguish between revisions on the data itself from revisions on the potential output generation process.

27 For the authors, the omission of inflation is wrong from a conceptual point of view, as financial imbalances may occur also when output increases along a non sustainable path in the absence of inflationary pressures, and also from a measurement perspective, as the financial cycle does take into account output cyclical components.

28 The authors include financial information in the measure of potential output derived from the HP filter.

predict more properly the true output cycle. Hence, this finance-neutral measure proves to be more accurate than the other available measures, robust in real time, and may provide reliable policy guidelines.

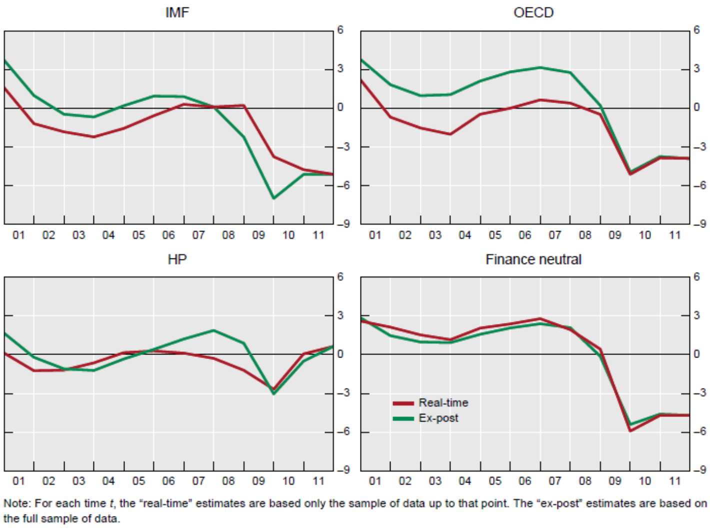


Figure 4: Different measures of output gaps, from Borio et al. (2013)

2.2.2.2 *Capacity utilization*

Berndt and Morrison (1981) and Nelson (1989) provide a theoretical background for the measurement of capacity and CU. Formally, physical capacity, meant as potential output, can be identified either as the minimum point of the Short-Run Average Total Cost Curve (SRATC) or as the point corresponding to the tangency between the Long-Run Average Total Cost (LRATC) Curve and SRATC. CU is usually referred to as the ratio between actual output and capacity, as defined above, and can be measured in three different ways, depending on the definition of capacity adopted:

1. An engineering definition:[29]

$$CU^o = \frac{Q}{Q_o} \tag{1}$$

   where Q_o is the maximum attainable output for a given short-run stock of capital;

2. An economic definition:

$$CU^t = \frac{Q}{Q_t} \tag{2}$$

   where Q_t is the output level corresponding to the tangency between LRATC and SRATC;

29 Berndt and Morrison (1981) state that this is a measure of "capital utilization rather than an economic measure of CU".

3. Another economic definition:

$$CU^m = \frac{Q}{Q_m} \tag{3}$$

where Q_m is the output level that minimizes SRATC.

As far as the measurement of CU is concerned, Nelson (1989) introduces a variable translog cost function to estimate Q_t and Q_m, in equations (2) and (3) respectively. The different estimations for CU are compared, and the author observes that both the economic definitions, CU^t and CU^m, are significantly greater than the engineering definition, CU^o,[30] suggesting that the Q_o measure may underestimate potential output. Also, CU^o may not be a good proxy for the real CU since its correlation with the two other classifications is relatively low. Such an evidence reveals that the engineering definition, often introduced in the literature, may not be a sound indicator for CU, and the author stresses, once more, the importance of identifying a good measurement for CU.

Berndt and Morrison (1981) observe that these theoretical definitions[31] fail to take into account the effect of energy price changes and state that existing measures of CU lost much of their explanatory power, mainly because of the weak link between them and the underlying economic theory. More specifically, they report that the increase in CU during the 1970s stemmed from the increase in energy prices, and not from an increase in investments and in average labour productivity. To fill this gap, they review the existing theoretical definitions of CU to predict the impact of changes in energy prices on CU, with capacity being the outcome of either profit-maximization (Y^{**}) or cost-minimization (Y^*), with $Y^{**} > Y^*$ if the exogenous output price is greater than the minimum of SRATC. Then, they define CU as $u = Y/Y^*$ and assess how input prices affect both Y^* and u, assuming that there are two factors of production: capital K, which is quasi-fixed, and energy E, which is instead variable. If the two inputs are Hicks-Allen substitutes, then, an increase in the price of E reduces Y^*;[32] if the two inputs are instead complements, p_E and Y^* move in the same direction. From an empirical point of view, the authors report two different approaches for the measurement of CU: the first is a dynamic cost function with one quasi-fixed input (capital), and the second is a model with two quasi-fixed factors (capital and skilled labour). As a last step, they empirically assess the impact of energy price changes of capacity output but observe only a small, though positive, relation between the two. The authors conclude that "applied researchers in the future will devote greater attention and care to the economic theory underlying the concept of capacity output". In another work, Berndt and Hesse (1986) estimate the capacity output of nine OECD countries by means of a

30 Respectively by an average of 16.4% and 25.4%.
31 Equations (1), (2), and (3).
32 The long-run level of capital and the long-run capital-output ratio must increase. Still, in the short-run, capital is fixed. Hence, capacity output must go down.

translog variable cost function. They find evidence of a pervasive excess capacity in the early 1980s and they trace it back to the rise in energy prices, whose impact on capacity output has considerably increased overtime. Once more, they find that this effect on capacity is small if compared to that of capital and labour.

Morrison (1985), despite the observed counter-cyclical behavior of CU, explains that "movements in certain cyclical measure are not random but can be viewed as systematic results of a rational economic optimization process undertaken by the firm" in a context of dynamic optimization. This dynamic model takes into account adjustments to optimal and desired level of capital, and CU[33] ultimately measures the shadow value of the quasi-fixed inputs.

Fare et al. (1989) consider the definition of capacity proposed by Johansen (1968), according to whom capacity is "the maximum amount that can be produced per unit of time with existing plant and equipment, provided that the availability of variable factors of production is not restricted", and extend the measurement of capacity to the plant-level. In this way, they obtain a definition of plant CU without specifying any particular functional forms. The mere observation of inputs and output generates in fact a maximum frontier output defined by

$$\Phi(x, k) = \max z \sum_{k=1}^{K} z^k u^k \tag{4}$$

where z is a vector of intensity variables that relates inputs and outputs (x^k, u^k). The authors apply this result to a sample of coal-fired steam-electric plants in Illinois in 1968 and evaluate the corresponding CU with either constant or variable returns to scale[34]

The reliability of CU data has been questioned also by Kennedy (1998), who compares the CU rates provided by the FRB with alternative time-series, obtained from HP-filtered industrial production data,[35] to come up with a measurement of CU that may explain inflationary pressures. This time-series performs equally well than the FRB measure, and the Granger causality test from CU to prices reveals the higher predictive power for inflation of industrial production time-series.

33 Defined as output over optimal output, given by the minimum of SRATC.

34 CU is defined as the ratio between either observed and capacity output, or observed output over installed generating capacity.

35 The author questions the consistency of the FRB measurement techniques, as some data have been excluded from the analysis and estimates have changed over time. Also, the definition of capacity adopted by FRB strongly relies on the underlying assumptions, and estimates may then be biased. The detrended time-series suggested by the author, that defines capacity as the stochastic trend in output, overcome these two issues as it is obtained from industrial production data (and is thus unaffected by the omission of relevant data).

2.3 OUTPUT, CAPACITY AND THE BUSINESS CYCLE

In this section, we review works that embed CU rates within Real Business Cycles, RBC. Usually, RBC models assume that, at each stage, the whole stock of capital is used, that the resulting equilibrium stochastic process is linear and that factor shares are constant.[36] Greenwood et al. (1988) consider a neoclassical framework with endogenous CU to explain how investment shocks are transmitted to the labour market. Positive shocks to the marginal efficiency of investment foster capital accumulation, and indirectly impact the rate of CU: future capital is more productive,[37] and changes in CU increase labour productivity, which in turn boosts consumption levels, increases the real wage rate and equilibrium employment.

The framework developed by Cooley et al. (1995) tries to add some realism to the RBC analysis and assumes that, at each stage, some capital is idle, with only the remaining part of the capital stock being subject to technological change. Without assuming a specific aggregate production function, the authors concentrate on the production decisions at the individual plant level[38] to assess the impact of technological change on aggregate fluctuations. The authors conclude that the cyclical properties of RBC are robust to the introduction of idle resources.

Hansen and Prescott (2005) consider a plant-level production decision similar to Cooley et al. (1995) to evaluate how capacity constraints, that are binding only when all plants are operative, affect the business cycle. They retrieve the individual production function with variable factor shares, since CU can vary, and show, once more, that the cyclical properties of business cycles are unaffected, although cycles are more asymmetric and the share of labour income is counter-cyclical.

Recent works also embed capacity-related issues in a context of monetary and financial cycles. For instance, Alvarez-Lois (2006) considers a model for monetary transmissions with macroeconomic propagation. Firms install capacity under demand uncertainty, and firms are constrained in the short-run with respect to factor substitution. These elements together may explain the rise of underutilized capacity. The author also assumes that uncertainty is idiosyncratic, which results in heterogeneous CU rates.[39] The author investigates firms' reaction, both in terms of production values and marginal costs, or wages, to mone-

36 As long as the aggregate production function is assumed to be a Cobb-Douglas.

37 As stated by the authors, this approach is more realistic than assuming direct shocks to the production function.

38 At each stage, the plant manager must in fact choose between operating the plant or letting the plant idle. The plant is operative if and only if it can generate enough output to cover labour costs. Each plant is subject to idiosyncratic shocks to technology.

39 In equilibrium, some firms may thus experience idle capacity and other firms may be producing at full capacity.

tary shocks:[40] firms that were previously experiencing excess capacity can expand their production facilities without incurring a significant increase in marginal costs, while other firms cannot match this extra-demand. Firms holding idle resources at equilibrium can now vary their CU rate, and the marginal cost of increasing production is lower than the marginal increase in production. Hence, this framework stresses the role of idle factors, such as capacity, in the transmission of the real effects of monetary policies.

Furceri and Mourougane (2012) investigate the effect of financial crises on potential output. The authors identify several direct transmission channels: first of all, demand is lower during financial crises, and inevitably reduces firms' incentives to invest in capital. Financial crises can also increase the structural unemployment rate, although their effect on labour participation rates is not well defined.[41] Also the effect of Total Factor Productivity, TFP, is to some extent ambiguous.[42] The authors also stress that policymakers' response to economic downturns may indirectly impact potential output and the long-term growth rate. They calculate potential output as the combination of TFP, tfp_t^*, capital stock, k_t^*, and employment, etp_t^*,[43]

$$y_t^* = tfp_t^* + (1-\alpha)k_t^* + \alpha etp_t^* \tag{5}$$

and estimate the following univariate autoregressive growth equation on 30 OECD countries from 1960 to 2008 to derive the impulse response function:

$$g_{it} = a_i + \sum_{j=1}^{4} \beta_j g_{i,t-j} + \sum_{j=0}^{4} \delta_j D_{i,t-j} + \varepsilon_{it} \tag{6}$$

where g is the annual growth rate of potential output, D is a dummy equal to 1 at the onset of a financial crises, and a_i are the country fixed

40 In this setting, final goods are sold in a perfectly competitive market, and the representative firm has a constant return to scale, CES function, $Y_t = \int_0^1 [(Y_{j,t}^{(\varepsilon-1)/\varepsilon})(\upsilon_{j,t}^{1/\varepsilon})dj]^{\varepsilon/(\varepsilon-1)}$, with the input elasticity of substitution equal to $\varepsilon > 1$, and where $Y_{j,t}$ is the quantity of intermediate input j used for the production of the final good j at time t. The supply of input j if fixed at $\bar{Y}_{j,t}$. The term $\upsilon_{j,t}$ in the production function reflects the realization of the idiosyncratic, productivity shock to input j, and can be rewritten as $\upsilon_{j,t} = \dfrac{\bar{Y}_{j,t}}{(P_{j,t}/P_t)^{-\varepsilon} Y_t}$, where $(P_{j,t}/P_t)$ is the market-power of the intermediate firm and Y_t is a spillover effect.

41 There is a positive effect (additional worker effect) from second-earners searching for a job to compensate for their income losses, but there is also a negative effect (discouraged worker effect) related to discouraged workers who give up looking for a job given the high unemployment rate.

42 R&D is in fact a pro-cyclical expenditure, and during economic downturns TFP goes down. Still, firms may have greater incentive to restructure and improve their productivity during downturns to reduce their losses.

43 Employment is defined as $etp_t^* = (1-u_t^*)h_t^* prlf_t^* pop_t^*$, where u_t^* is the structural unemployment rate, h_t^* is the the number of hours worked, $prlf_t^*$ is the participation rate, and pop_t^* is the working age population.

effects. This empirical strategy allows the authors to find the overall[44] impact of financial crises on potential output, and they observe that financial crises tend to reduce potential output by an average $1.5\% - 2.4\%$.[45]

The erosion of potential output during financial crises emerges also in Bijapur (2012), that looks at the effect of financial crises in 9 OECD countries after 1990. The author estimates the Phillips curve to predict the growth inflationary component following financial crises, and observes that recovery from financial crises needs higher inflationary pressure relative to other economic downturns. This increase in inflation is detrimental to potential output.

Also Benati (2012) focuses on the consequences of financial turmoils on the potential output of few selected countries.[46] By means of a Blanchard-Quah decomposition,[47] the author exploits the following VAR model to estimate the log natural real GDP:

$$Y_t = B_0 + B_1 Y_{t-1} + \cdots + B_p Y_{t-p} + \epsilon_t \quad (7)$$

where $Y_t \equiv [\delta y_t, X_t]'$ and where y_t, X_t respectively are the log-difference of real GDP and a vector of covariance-stationary covariates. The author finds that, with a probability equal to 88.8% and 79.9% respectively, the growth rate of potential output in the Euro area and in the USA respectively fall by -0.9% and -1.3% between the collapse of Lehman Brothers and 2011Q1. The UK faced a more severe decline, as the growth rate slowed down by -4.4%.

Another branch of economic theory looks at the sustainability of collusive agreements when demand is volatile and firms are capacity constrained. Fabra (2006) investigates how capacity constraints affect the sustainability of collusive agreements under business cycles fluctuations,[48] and shows that "that the issue of whether firms find it more difficult to collude during booms or recessions is linked to the value of firms' capacities". In this setting, homogeneous firms initially make

44 Hence not country-specific.

45 Most of the effect is related to capital.

46 The Euro Area as a whole, the United States, Japan and the UK.

47 The author hence introduces the original level variables of Blanchard and Quah (1989) to overcome the stationarity and correlation with the business cycle of the unemployment rate.

48 This work is an extension to Haltiwanger and Harrington (1991), that study the sustainability of collusive agreements under demand uncertainty without capacity constraints. In a nutshell, the authors show that agreements are less sustainable during downturns. Also Green and Porter (1984) look at the stability of collusive behavior with uncertain demands. In their specification, demand fluctuations are not observed by firms, but cycles can still affect the performance of the industry, and may lead to unstable productions. Firms may act either as monopolists or as Cournot players, depending on the price realization. Firms agree on a "trigger price", according to which they decide their behavior: if the market price falls below this trigger price, then the two firms acts as monopolists; if instead the market price is greater than the trigger price, than two two firms temporarily play Cournot competition before going back to their monopolist behavior.

their simultaneous pricing decisions,[49] and an efficient rationing rule allocates sales.[50] When capacity constraints are sufficiently binding, and installed capacities are relatively small, collusion is less sustainable during economic expansions, since firms cannot satisfy excess of demand and punishment from deviations are low. For sufficiently large capacities, agreements can instead be more easily sustained. On the other side, economic downturns may lead to the rise of excess capacity and the economic consequences of deviation would be more intense.

2.4 A THEORETICAL EXPLANATION FOR PHYSICAL AND EXCESS CAPACITY

The industrial organization literature on physical capacity owes a significant research effort to the seminal contribution of Cournot and to his quantity competition setting. In the last century, researchers have extended the implications of strategic interaction by considering also investment decisions. It is in this precise framework that the concept of physical capacity emerges. Overtime, authors have set up different models and different games to understand the determinants of firms' capacity investment decisions.

2.4.1 *Why?*

Why do firms invest in physical capacity? The answers provided so far by the industrial organization literature have identified three major explanations: investments in physical capacity can be the result of strategic interaction, of demand uncertainty, and of rising international competition.

As far as strategic interaction is concerned, the seminal contributions by Spence (1977) and Dixit (1979) identify initial output commitment as the best entry deterrence response. More specifically, Spence (1977) considers a two-stage game between an incumbent and a potential entrant, with both firms producing the same homogeneous good. The author develops two different models: in the first one, capacity does not affect marginal costs, whereas in the second specification, marginal costs are decreasing in capacity. The two cost structures are

$$C(x,k) = c(x) + rk \qquad\qquad C(x,k) = c(x,k) + rk \tag{8}$$

where x is output and k is capacity, and where $c_{xk} < 0$ in the second specification. When there is an entry threat, the established firm

49 Production above capacity implies an infinite cost and hence is ruled out.

50 Consumers initially buy from the low-cost firm; once its capacity has been exhausted, consumer start buying from the second low-cost firm, and so on, until the capacity of the high-priced firm is exhausted, too.

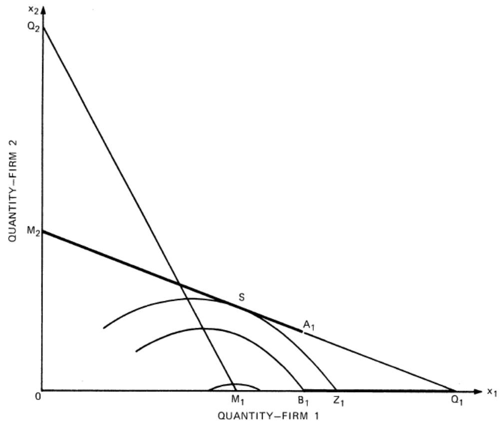


Figure 5: Reaction functions with fixed costs, in Dixit (1979)

chooses a level of capacity k to reduce the post-entry price and the entrant's profits. In either model, entry is deterred if

$$P(k+y) \leq a(y,y) = \frac{C(y)}{y} + r \quad \bar{P}(k,\hat{k}) \leq \frac{C(\bar{y}(k,\bar{k}),\hat{k})}{\bar{y}(k,\hat{k})} + r\hat{k} \tag{9}$$

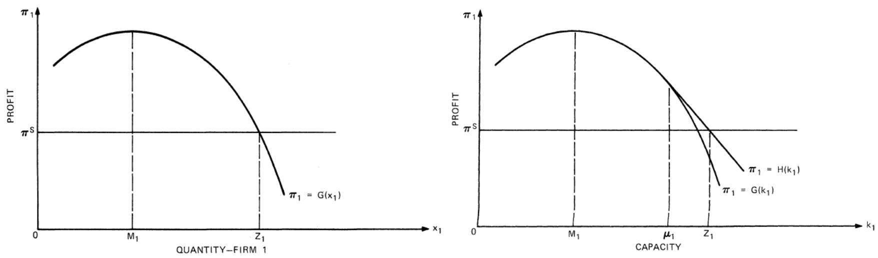
Under the first cost specification, entry is deterred if the post-entry price $P(k+y)$, where k is the incumbent's output and y is the entrant's supply, falls below the entrant's average costs. Then, the incumbent maximizes its profits with respect to k and x under two constraints: $x \leq k$, to ensure profit maximization, and $k \leq \bar{k}$, to ensure entry deterrence, as $\bar{k}$ is the minimum level of capacity needed to block entry.
The second equation of (9) refers to the second model specification. In this case, entry is blocked once again if the post entry price is lower than the entrant's average costs when it produces $\hat{k}$. The minimum level to deter entry is $\bar{k}$, so the established firm must maximize profits subject to the constraint $k \geq \bar{k}$. In this setting, the incumbent chooses to hold excess capacity in order to deter entry in the next stage of the game. If, on one side, this irreversible investment decision successfully deters entry, on the other side it makes production inefficient, as the corresponding price will excess the limit price. Still, this model offers an innovative approach for interpreting investment decisions, as the author clearly states that "existing firms choose capacity in a strategic way designed to discourage entry".

Dixit (1979) considers a quantity competition game between one incumbent and one large entrant and investigates how the incumbent deals with entry threats. The author introduces fixed costs, thus affecting reaction functions, which are now discontinuous, as displayed in Figure 5.[51]

Depending on the magnitude of fixed costs, there are multiple equilibria: both firms are active, or there is only one firm, acting as a monopo-

51 With the point of discontinuity depending on the level of fixed costs.

list.[52] The author considers two different cases: in the first one, known as the Sylos postulate, the level of output chosen by the incumbent is constant, also after entry. In the second specification, he assumes that the incumbent threatens entry by choosing a sufficiently large value of output: to make this strategy credible, the incumbent must hold enough capacity already before entry. The introduction of capacity affects the entry-deterrence and the entry-accommodation zones. Figure 6 displays the different acceptance/deterrence regions of each specification.
In the first case,[53] if fixed costs are small, entry cannot be impeded, and the two firms play Stackelberg competition, which occurs for $B_1 > Z_1$. If fixed costs are large, the firm chooses not to enter (hence entry is blocked) and the incumbent acts as an unrestrained monopolist, which occurs for $B_1 < M_1$. For intermediate fixed costs, the incumbent applies the limit price strategy to block entry, but in this way it cannot act as an unrestrained monopolist. This occurs for $M_1 < B_1 < Z_1$.
In the second specification instead, for $B_1 < M_1$ entry is blockaded; for $M_1 < B_1 < Z_1$ entry is deterred by the limit price strategy;[54] for $M_1 < B_1 < Z_1$ entry is deterred by the excess capacity strategy, and for $Z_1 < B_1$ entry is accommodated. Thus, the existence of a sufficiently high level of capacity helps the incumbent to successfully deter entry, and eventually increases the area in which entry is effectively impeded.



(a) Sylos Postulate (b) Excess capacity

Figure 6: Entry deterrence and entry accommodation, from Dixit (1979)

Dixit (1980) considers a framework similar to Dixit (1979) to introduce irreversible investment decisions. The initial level of capacity chosen by the incumbent affects in fact the post-entry marginal cost curve, its reaction curve and the post-entry game conditions. In this framework, the outcome of the entry decision can lead to either Cournot competition, in case of entry, or to a monopolist scenario, in case of

52 If fixed costs are small, the discontinuity point lies in an irrelevant region and the Cournot Nash equilibrium is unaffected. If instead fixed costs are large for the entrant, there can be two equilibria.
53 As displayed in the left-hand side picture.
54 With output $x_1 = \mu_1$ and capacity $k_1 = B_1$.

no entry. According to the choice of capacity $\bar{k_1}$, the incumbent's cost specification is

$$C_1 = \begin{cases} f_1 + r_1\bar{k_1} + w_1 x_1 \text{ if } x_1 \leq k_1 \\ f_1 + (r_1 + w_1)x_1 \text{ if } x_1 \geq k_1 \end{cases} \quad (10)$$

Equilibrium thus depends on the choice of output x_2 of the entrant, as this choice affects the marginal revenues of firm 1; to act as a leader, the "established firm can exercise leadership over a limited range by using its capacity choice to manipulate the initial conditions of that game". So the incumbent can effectively implement the leadership strategy, thanks to the capacity choice, only over a limited range: as long as the two firms play according to Nash equilibrium rules, there is no over investment in capacity by the incumbent, thus in contrast with the over-capacity prediction of Spence (1977).

The second rational for over-capacity has to be found in the contributions that include demand uncertainty. The work by Spencer and Brander (1992) considers alternative quantity duopolies, and look at how the introduction of demand uncertainty affects the trade-off between commitment and flexibility, as the option-value of flexibility[55] may be offset by strategic interaction. The authors consider three different settings. The first model is a Stackelberg output leadership model, with the incumbent choosing between making an initial commitment or waiting for demand realization. Still, if demand is sufficiently uncertain, the incumbent prefers to wait for demand realization. In the second scenario, both firms can decide whether to invest before or after demand resolution: they introduce firm-specific uncertainty and observe the rise of a natural leader. As a last step, they look at how uncertainty over the rival's cost affects the incumbent's trade-off.

Gabszewicz and Poddar (1997) investigate "the impact of uncertain demand on firms' capacity decision when they operate in an oligopolistic environment". In their model, two identical firms face a linear demand with a random intercept. Firms install capacity unaware of which state of nature will realize in the second stage. Only after the resolution of uncertainty, firms produce. The authors find a symmetric subgame perfect equilibrium in which both firms hold excess capacity, with respect to the capacity they would have chosen in the Cournot certainty equivalent scenario. In the symmetric subgame perfect equilibrium characterization, both firms choose

$$k_1^* = k_2^* = k^* = \frac{1}{3}\left[\frac{\sum_{i^*+1}^{n} \rho_s A_s - \beta}{\sum_{i^*+1}^{n} \rho_s} - \gamma\right] \quad (11)$$

where A and ρ are respectively the demand intercept and the objective probability of the state of nature s, β is the marginal cost of capacity,

55 Flexibility has an option value as firms delay their investment decisions and wait for the realization of demand.

γ is the marginal cost of production, and i^* denotes the threshold state in which firms choose to be capacity constrained. The authors thus compare equation (11) with the outcome of the certainty equivalent case:

$$\hat{k_1} = \hat{k_2} = \hat{k} = \frac{\sum_{s=1}^{n} \rho_s A_s - (\beta + \gamma)}{3} \tag{12}$$

with $\hat{k} = k^*$ if and only if both firms choose to be constrained in all states ($i^* = 0$). Otherwise, firms under uncertainty hold more capacity than what they do in the certain case, with $k^* > \hat{k}$.

Also Pindyck (1988) investigates the impact of uncertainty on firms' capacity choices, by considering the joint impact of investment irreversibility and demand or cost uncertainty.[56] The author observes that the sunkness of investment decisions, when demand is uncertain, should decrease the optimal level of capacity held by firms. That is, with volatile demand and irreversible investments, firms should invest less in capacity than what they would, were investment decisions not sunk.

The third explanation for the existence of excess capacity relies in the contribution of Fagerberg (1988). This model measures international competitiveness $S(X)$ as a function of three factors: capacity C, technological competitiveness (T/T_w), and price competitiveness (P/P_w), as represented by

$$S(x) = AC^v \left(\frac{T}{T_w}\right)^e \left(\frac{P}{P_w}\right)^{-a} \tag{13}$$

Total differentiation with respect to time leads to

$$\frac{dS(x)}{S(x)} = v\frac{dC}{C} + e\left(\frac{dT}{T} - \frac{dT_w}{T_w}\right) - a\left(\frac{dP}{P} - \frac{dP_w}{P_w}\right)$$

where $\dfrac{dC}{C}$ represents the ability to deliver demand and can be further decomposed into

$$\frac{dC}{C} = z\frac{dQ}{Q} + r\frac{dK}{K} - l\frac{dW}{W} \tag{14}$$

where (dQ/Q) is the growth in technological capability, (dK/K) is the growth in physical capital, and (dW/W) is the rate of growth of demand. This last factor explains how capacity choices and relative international competitiveness are related. With fixed capacity, capacity constrained countries may not be able to deliver and satisfy final demand: under excess demand, a capacity constrained country may not be able to fully satisfy demand. The country's total exports may not vary, but its export share would inevitably goes down as other countries

56 From this perspective, irreversibility affects the investment opportunity cost: the 'Net Present Value' rule cannot hold in such a context, as the value of the invested unit must be greater than the purchase and installation costs.

might serve the residual demand. Hence, the model of Fagerberg (1988) suggests that investments in capacity impact the country's ability to serve final demand and consequently its international position. The author also considers the effect of demand on CU, as it might stimulate capacity expansion and contribute to international competitiveness.

2.4.2 *How?*

2.4.2.1 *Pure oligopolies vs. mixed oligopolies*

In addition to the standard pure duopoly representation, some works analyze capacity investment decisions in mixed settings. The mixed framework developed by Stewart (1991) consists of two firms, a profit maximizing one, and a labour managed one. In this sequential game, with the incumbent being of either organizational form, the nature of the entrant affects the incumbent's entry acceptance or deterrence. When the incumbent is of the labour managed type, there can be excessive investment in capacity to deter entry. A similar result emerged in the framework suggested by Zhang (1993), where the incumbent in a labour managed industry, under a Leontief production function with 0 elasticity of substitution, carries overcapacity to deter entry. The robustness of this result has been tested in a note of Haruna (1996), where a more generic constant returns to scale function is assumed.

The analysis of mixed duopolies can also entail competition between a public and a private firm. The repeated game by Wen and Sasaki (2001) can give rise to excess capacity by the public firm, as the result of a trigger strategy to sustain a Subgame Perfect Equilibrium. Moreover, for an endogenous level of capacity, excess capacity can occur when the public firm is less efficient in the capacity investment than the private one. In this case, excess capacity is welfare enhancing as long as the additional benefits from increased output more than offset the higher investment costs. Differently from this result, Nishimori and Ogawa (2004) find that the public, and non-profit maximizing firm chooses to be the market follower by choosing to under invest in capacity, and letting the private, and profit maximizing firm to carry, strategically, excess capacity. The cost function assumed by Nishimori and Ogawa (2004) is

$$C_i(q_i, x_i) = m_i q_i + (q_i - x_i)^2 \tag{15}$$

where q is output, x capacity and with $i = a, b$, for the private and public firm respectively, and with $m_a < m_b$. This cost specification is the same of Lu and Poddar (2006). Also in this two-stage game, with the introduction of demand uncertainty, the public firm may prefer to under-invest in capacity and let the more efficient, private firm to produce more so as to increase total welfare. Still, this result occurs for medium realizations of final demand. If demand is in fact sufficiently high or low, a symmetric equilibrium, with both firms either under or over investing in physical capacity, emerges.

2.4.2.2 *Pure quantity competition vs. quantity and price competition*

In most works, excess capacity rises in pure quantity competition games, in which firms initially install capacity and then produce by adjusting their output levels. Still, the seminal contribution by Kreps and Scheinkman (1983), KS, embeds capacity decisions in a context of quantity and price competition to mitigate critics of Cournot model. Their setting entails competition over homogenous products and includes a rationing rule that determines the demand of the high-price firm when the low-cost firm is capacity constrained and is not able to serve the whole market, as summarized by Martin (1999), and leads to the same equilibrium of the standard one-shot Cournot game.

Quantity and price competition games also gained attention in the analysis of collusive agreements. More specifically, colluding firms may want to carry excess capacity to support collusive agreement and use this excess capacity as an effective threat for deviations. For instance, in the first stage of Benoit and Krishna (1985), firms initially make their investment/capacity decisions, and then engage in an infinite price competition game. The authors introduce collusion on either prices or quantities. Firms' threats reduce initial investment in capacity, ultimately increasing collusion possibilities. Still, all the possible equilibria, except for the Cournot-Nash one, are characterized by firms carrying excess capacity, and firms can charge higher prices with respect to the Cournot-Nash price. Davidson and Deneckere (1990) extend Benoit and Krishna (1985) to analyze the link between excess capacity and price collusion, thus ruling out collusive agreement over quantities: in the first stage, firms choose their capacities, and, in the second stage, they charge the highest collusive sustainable equilibrium. The authors thus look at these "semi-collusive" equilibria and observe that firms choose to carry excess capacity at all equilibria, also in the Cournot-Nash one, to threaten punishment in case of deviations.[57]

Acemoglu et al. (2009) study the efficiency of oligopoly equilibria under a KS framework, with efficiency being the ratio between surplus in equilibrium and surplus under the first best scenario. When doing so, they follow two alternative approaches:[58] the "Price of Anarchy" approach, and the "Price of Stability" approach.[59] The authors observe that, also under a very simple linear cost function, the Price

57 Davidson and Deneckere (1990) also observe that firms increase their excess capacity and collude more frequently as interest rates and costs of capacity fall. Increasing interest rates reduce losses after deviation, and thus undermine the stability of collusion.

58 Given the fact that there are multiple pure strategy equilibria.

59 In case of multiple equilibria, these two approaches respectively selects the parameters of the worst equilibrium, and the best equilibrium for any set of parameters and then considers the worst-case parameters.

of Anarchy is zero, suggesting that equilibrium is arbitrarily inefficient. When implementing the Price of Stability approach, the authors observe that, under the socially optimum equilibrium, the "maximum inefficiency that may result from capacity competition is no more than approximately 1/6 of the maximal social surplus". Their evidence thus explains that inefficiencies from choosing a non-optimal equilibrium may be significant, but under a proper equilibrium, the KS competition guarantees sufficient efficiency.

In a recent work, Tumennasan (2013) extends KS and includes price-matching at the second stage. In this context, the effect of price-matching on the outcome of price competition depends on the magnitude of capacity constraints: it is relevant in large capacity industries and less significant when capacity is low.[60] The author also shows that the impact of price-matching depends on the cost of installing capacity if capacities are installed simultaneously; if the cost is relevant, price-matching lowers the equilibrium price.[61]

2.4.2.3 *Static vs. dynamic games*

The contributions analyzed so far consist of static games in which competition takes place in a two-stage framework: firms initially install capacity and then produce, either by choosing output adjustments or prices. Still, games with capacity may entail a dynamic setting, as in Abel (1981), where firms must decide, at each stage, their optimal utilization rates of both capital and labour. Under convex adjustment costs, the investment in each factor[62] of production is increasing in the shadow price of the factor itself. The author also observes that the optimal utilization rate is increasing in the capital-labour ratio as long as the stock of capital increases, holding the labour stock constant.

Excess capacity also emerges in the context of dynamic games, as it occurs in Besanko et al. (2010). In their infinite horizon set up, firms face demand uncertainty at each stage of the game, when they must choose between positive and negative capacity adjustments. Still, one firm does not know nor what its rivals are going to do nor its rivals' adjustment costs: one firm only knows the rivals' investment/disinvestment probability. The model is solved numerically, and two extreme Markov-perfect equilibria emerge, each with a different swing producer. In one case, the swing producer is the large firm that acts as a monopolist and adapts its capacity to meet demand fluctuations. In the other extreme equilibrium, smaller firms act as swing producers and the large firms keeps its capacity constant.

60 For intermediate values of capacity, small firms benefit from price-matching as large firms have less incentives to cut prices.
61 Effects are ambiguous for low installation costs.
62 Which the author refers to as quasi-fixed factors.

2.5 CONCLUSIONS

Recent financial downturns and the rise in demand uncertainty seriously threatened the sustainability of industrial capacity investment decisions. Despite some explanations for excess capacity have already been suggested, firms still make wrong investment decisions. Hence this paper stresses the importance of further investigating the factors that impact capacity installation, so as to endow firms with specifically designed policies and tools.

More specifically, researchers should take into account country and sector specific elements that play a role during investment decisions. As far as country specific factors are concerned, future research should look at the role played by the institutional background.[63] Also sector specific characteristic may play an unquestionable role: this is why future research should also assess the impact of a sector capital intensity.[64]

Prevention is (undoubtedly) better than cure; still, future research should also analyze the consequences of excess capacity, both at the micro and macro level. On aggregate terms, the impact of negative output gaps on the economic fundamentals should be better singled out. Future research should also consider the local impact of excess capacity. Persistent excess capacity may trigger plant closure and firm exits: what are the local consequences of this? What happens, for instance, to the housing market, in terms of prices, mortgage default rates, sales, as a local community goes through a plant closure? And how would this shock affect people's mobility and migration towards better working opportunities?

63 To this purpose, Chapter 3 investigates the impact of labour market rigidity on the accumulation of excess capacity.

64 As preliminarily done in Chapter 4, where the effects of capital intensity and labour market rigidity are jointly analyzed.

3

COUNTRY-SPECIFIC RIGIDITIES AND INVESTMENT DECISIONS: QUANTITY COMPETITION AND DEMAND UNCERTAINTY

Abstract

This paper relates excess capacity to the stiffness of labour institutions, which may contribute to the accumulation of over capacity. In our two-stage game, two firms in two countries install capacity, under demand uncertainty, and then adjust output using labour, by producing above or below capacity, with asymmetric adjustment costs reflecting different labour regulations. Firms invest in capacity only for positive expectations over final demand, to minimize the impact of future adjustment costs. The firm in the high-cost country moves even closer to firms' expectations, and installs more capacity, to the potential detriment of the other firm. Hence, under factor substitutability, higher labour costs make firms prefer output commitment over flexibility.
An alternative technology specification, with capacity-labour complementarity, is introduced to make the impact of labour costs less severe and to alleviate the issue of excess capacity.

Keywords: Industrial organization, Oligopoly,

JEL Classification: L, L13.

3.1 INTRODUCTION

Economic downturns may trigger negative output gaps both at the aggregate and micro level, and firms experiencing excess capacity reduce their CU rate by keeping their plants partially idle.[1] Two figures show the impact of the recent global downturn. Figure 7 reports, at the aggregate level, potential output,[2] output gap,[3] and the real GDP per-capita for a sample of OECD countries.[4] The aggregate output gap

1 As an example, in less than 3 years the CU rate of Italian automotive plants dropped from a break-even level of 80% to 50%, as reported by "'Il Sole 24 ore"'.
2 Meant as the maximum amount of goods and services that can be produced by an economy in a given time range.
3 Expressed as the percentage deviation from potential output.
4 Countries included are: Australia, Austria, Belgium, Canada, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Korea, Luxembourg, Netherlands, Norway, Poland, Portugal, Slovak Repub-

has been decreasing since the onset of the financial crises in 2007, and has been persistently negative since 2009. Figure 8, at the micro level, displays the Industrial Production Index for a group of European countries.[5] Taking year 2000 as the base year, this Figure clearly shows the aggregate drop of industrial production in 2008.

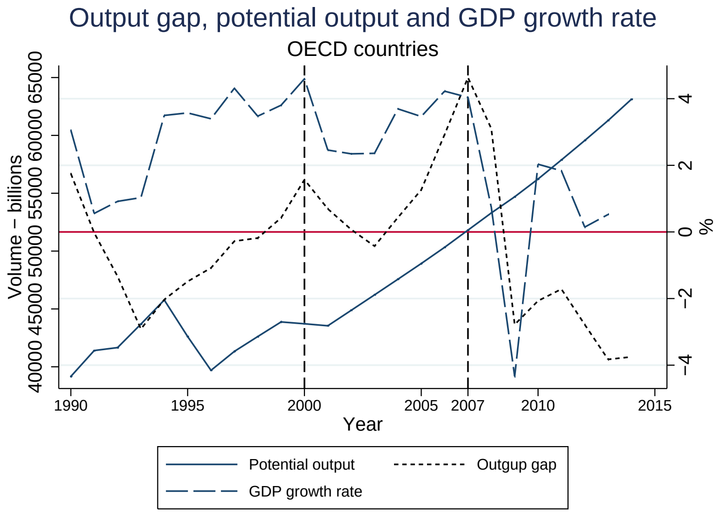


Figure 7: Potential output and output gaps

Persistent negative output gaps and falling production suggest that the analysis of firm's investment behavior is far from being complete. Capacity building is perhaps the most relevant investment decision firms have to make. What factors do firms take into account at this preliminary stage? The existing literature traces over-investment in capacity back to either strategic interaction or demand uncertainty, as already underlined in Chapter 2.[6] Empirical works estimate the impact of labour market rigidity on firms' capital-labour ratio: Autor et al. (2007) observe a positive impact of Employment Protection Legislation, EPL, on US firms' capital-labour ratio, whereas Cingano et al. (2010) predict a negative relation in financially constrained European firms. These contrasting evidences have been reconciled by Janiak and Wasmer (2012), where a generally negative link between capital and

lic, Slovenia, Spain, Sweden, Switzerland, United Kingdom, and United States, from 1990 to 2014.

5 Data on production are gathered from the production volume of country-sector OECD Stan Database and have been aggregated at the country level. The countries included in the sample are: Austria, Belgium, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Luxembourg, Netherlands, Poland, Portugal, Slovak Republic, Slovenia, Spain, Sweden, and United Kingdom from 1990 to 2010.

6 See Spence (1977), Dixit (1979), Brander and Lewis (1988), Spencer and Brander (1992), and Gabszewicz and Poddar (1997).

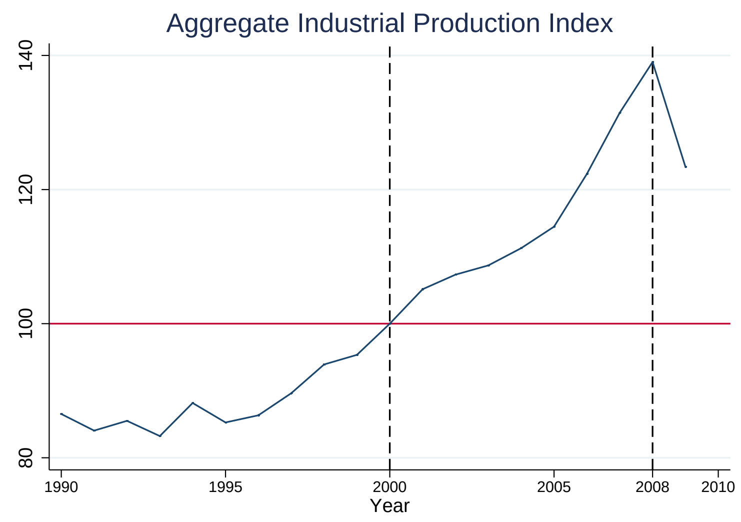


Figure 8: Industrial Production Index

labour emerges. Still, this relation can be positive if the two factors of production are sufficiently complementary, as displayed in Figure 9.[7]

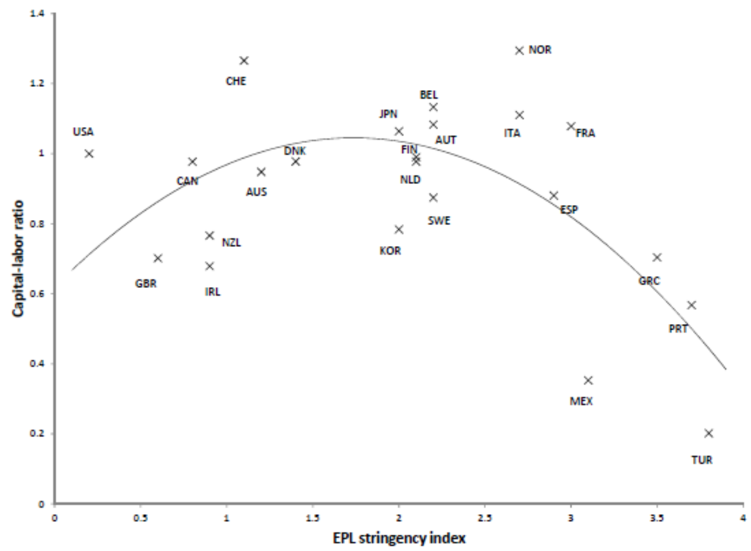


Figure 9: EPL and capital-labour ratio, from Janiak and Wasmer (2012)

Notwithstanding these empirical contributions, the existing theoretical literature fails to relate institutional rigidities to firms' investment decisions, as explained by Cingano et al. (2010): "while theoretical mod-

7 To contextualize this analysis, they relate the cross-country EPL to the capital-labour ratio index provided by Caselli (2005). As Figure 9 shows, there is an inverse U-shaped relationship between EPL and the capital-labour ratio: the capital-labour ratio is increasing in EPL up to a certain threshold, (EPL equal to 2, where EPL ranges from 0, absence of labour protection, to 6, maximum protection) as it occurs for the United Kingdom and the United States, but then it starts decreasing, as confirmed by Italy and Greece among others.

els offer clear predictions regarding the effects of adjustment costs on job turnover, they provide no guidance on the expected effects of employment protection laws on capital investment, the capital-labour ratio and productivity".

Our paper fills this gap and suggests a new explanation for excess capacity. We set up a two-stage quantity competition game between two firms in two countries: firms initially invest in capacity according to their expectations over final demand, and, once uncertainty has resolved,[8] firms employ labour to adjust output.[9] Adjustment costs are country-specific, and we let these asymmetries account for the country labour market regulation.[10] We solve the model by backward induction to predict the impact of future labour adjustment costs on capacity decisions. In other words, we assess how firms solve the commitment vs. flexibility trade-off in countries with different labour legislation.

Interestingly, we observe that firms install capacity only if they have positive expectations over final demand, with firms moving closer to their expectations so as to minimize the impact of future adjustment costs. Also, the firm facing higher labour costs has an extra incentive for over-investing in capacity, and it thus commits to a higher level of output, potentially to the detriment of the firm in the low-cost country, that installs less capacity. If final demand is low, that is, if the magnitude of the shock is not too large, the more committed firm gains higher ex-ante and ex-post profits. For a large shock, the more flexible firm can adjust more and satisfy a larger residual demand, with positive repercussions on its own profitability. If expectations over final demand are instead neutral or negative, firms do not install any capacity and rather wait for demand realization. These predictions hold under the assumption of a simple technology, with capacity and labour being perfect substitutes. In an extension, we relax this assumption and introduce capacity-labour complementarity. This new technology makes the impact of labour cost differentials less severe and may alleviate the issue of excess capacity.

3.1.1 *Stylized facts*

Tables 1 and 2 support the main predictions of our model. Table 1 estimates the impact of labour costs on the formation of potential output in OECD countries,[11] and confirms the substitution effect observed

8 We assume that one exogenous shock symmetrically hits demand before the second stage.

9 Adjustments can be either positive or negative, depending on the shock.

10 From now on, we will be referring to the rigid (flexible) labour country as the high (low) cost country, to avoid confusion with the output commitment vs. output flexibility trade-off faced by firms.

11 Using aggregate data.

in the model,[12] with labour costs displaying a positive and significant effect on the accumulation of production capacity.[13] We obtain very similar results when estimating the impact of wages on the potential output of the automotive industry,[14] as shown in Figure 10.[15]

Log Potential Output	(1)	(2)	(3)	(4)
Unit labour cost	0.312***	0.108***		
	(0.087)	(0.107)		
Log GDP per capita		0.630***		0.527***
		(0.138)		(0.133)
Log labour compensation			0.359***	0.165***
			(0.089)	(0.080)
Year FE	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes
R^2	0.869	0.935	0.905	0.940
N	610	610	629	629

* significant at 10%; ** significant at 5%; *** significant at 1%

Robust Standard errors in parentheses.

Table 1: Potential output and labour costs

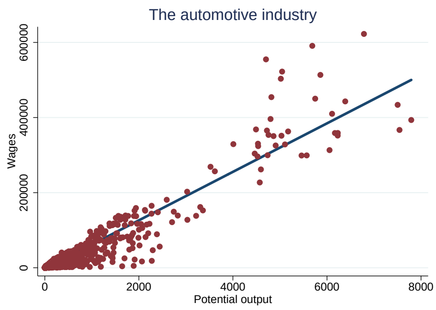
In Table 2, we perform a diff-in-diff analysis to evaluate the impact on aggregate potential output in those OECD countries where EPL

12 The result is robust to two alternative cost specifications: unit labour costs, defined as the ratio between total labour costs and real output, and the compensation rate.

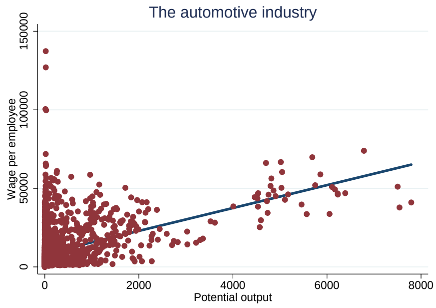
13 In these specifications, we also control for the effect of the business cycle, and for demand fluctuations, by including the log of real GDP per-capita, which also shows a positive and significant effect on the accumulation of potential output.

14 In this analysis, we retrieve data from Indstat 2013 ISIC Rev.3, which provided the greatest number of observations for the automotive industry. Because of gaps in the time series, we estimated potential output by means of a capital intensive Cobb-Douglas production function, using capital formation and employees as production inputs. This analysis include 142 countries, from 1963 to 2010. Automotive industry data are at the 2-digit level, and so they include the automotive value chain as a whole. Still, generally speaking, automotive suppliers tend to be located close to the final assembly plant: hence, most of the components are designated for the same country assembly plants and contribute to the country potential output.

15 The two sub-figures respectively display the relation between potential output, in $100,000 and total wages and wages per employee, both in $100,000.



(a) Total wages



(b) Wages per employee

Figure 10: Potential output and wages in the automotive industry

increased overtime.[16] We look at the two-year effect and at the multi-year effect, estimating the following equations:

$$Potential\_output = \beta_0 + \beta_1 t + \beta_2 treated + \beta_3(t * treated) + \beta_4 GDP + \beta_5 Stock\_Capital + u \tag{16}$$

$$Potential\_output = \beta_0 + \beta_1 dummy\_year + \beta_2 treated2 + \beta_3(t * treated2) + \beta_4 GDP + \beta_5 Stock\_Capital + u$$

where $t = 1$ in 2012 and $t = 0$ in 1995; $treated = 1$ if $EPL_{2012} > EPL_{1995}$, and 0 otherwise, $dummy\_year$ is the multi-year dummy, and $treated2 = 1$ if the annual growth rate of EPL is positive.[17] The coefficients of the two interacted terms, $t * treated$ and $t * treated2$, are the differences we are interested in. They are both positive and significant,[18] suggesting that countries experiencing an increase in labour

16 EPL substantially considers firing restrictions, hence an increase in EPL imply higher firing costs.
17 We divided the original measure of potential volume by $10,000,000,000,000$.
18 The coefficient in the multi-period specification (2) is significant at 14%.

protection also experience an increase in the overall potential output that can be traced back to changes in labour regulation.

Potential output	(1)	(2)
t	-2.816**	
	(1.130)	
treated	0.000	
	(.)	
t*treated	**2.093***	
	(1.046)	
GDP	-0.395**	-0.157
	(0.182)	(0.165)
productive capital stock	0.000***	0.000***
	(0.000)	(0.000)
treated2		-0.925
		(0.898)
t*treated2		**1.756**
		(1.141)
Country FE	Yes	Yes
Year FE	No	Yes
R^2	0.981	0.980
N	51	51

* significant at 10%; ** significant at 5%; *** significant at 1%

Standard errors are reported in parentheses.

Table 2: Diff-in-diff on aggregate potential output

This macro and micro empirical evidence predicts a positive impact of labour regulation on the accumulation of physical capacity, thus confirming the predictions of this paper and stressing the importance of understanding what's behind firms' investment decisions. In addition to demand uncertainty and strategic interaction, there are indeed other reasons that explain the rise of excess capacity. This paper in fact provides a new explanation, that relates physical capacity to the labour institutional background.[19]

This paper is structured as follows: Section 3.2 introduces the main related literature; Section 3.3 describes the consumption and cost sides and develops the main model; in Section 3.4 we assume capacity-labour

19 In Annex A.1.1, we perform a probit analysis to evaluate the impact of increases in labour costs on the probability of incurring negative output gaps . Results show, once more, the role of labour market rigidity: as labour costs increase, the probability of experiencing excess capacity increases by 0.55.

complementarity, and in Section 3.5 we introduce more costly negative adjustments; last, Section 3.6 draws the main conclusions.

3.2 LITERATURE REVIEW

This paper heavily relies on the seminal contributions of Spence (1977), Dixit (1979), Dixit (1980), who investigate the role of strategic interaction within quantity competition. According to Spence (1977), the incumbent's quantity commitment, which is assumed to be invariant with respect to the entrant's decision,[20] is an effective entry deterrence tool. By preserving this constant commitment assumption,[21] Dixit (1979) further examines the incumbent's entry deterrent output commitment in a context of product differentiation. In an extension to this model, the author also studies how an excessive commitment would credibly threaten the inactive firm, by intimidating it with a predatory output in case of entry. In his seminal contribution, Dixit (1980) allows for ex-post adjustments.[22] In this way, the established firm could alter the initial conditions of the game[23] by changing the post-entry structure of its marginal costs.

The implications of product differentiation within quantity competition have been further analyzed by Kreps and Scheinkman (1983), who extend Dixit (1980) by embedding product differentiation in a two stage game framework: firms simultaneously set their capacities and, once aware of the competitor's optimal investment, engage in price competition. The fundamental prediction of this model is that equilibrium is not only unique but it corresponds exactly to the standard Cournot outcome.

The role of output commitment has also been analyzed by Spencer and Brander (1992), who look at how firms solve the commitment-flexibility trade-off in a context of economic uncertainty.[24] They consider alternative settings of oligopolistic competition to show that demand uncertainty affects the way firms solve this trade-off, and they stress the importance of pre-commitment as an entry-deterrent strategy.

This trade-off has also been analyzed by Dewit et al. (2013), with a focus on firms' location decisions. They consider in fact a two-period setting, in which firms initially have to choose where to produce and then engage in either quantity or price competition. At the time of picking their production location, firms must choose between a country with a flexible labour legislation and a country with a rigid employ-

20 That is, the quantity commitment is constant even in case of no-entry in the second stage.
21 Also known as the Sylos Postulate.
22 Even though the only admitted adjustment is positive, so that investments can only increase.
23 Which are however assumed to be exogenous.
24 Modeled as an exogenous, demand additive, shock.

ment protection. The underlying level of employment protection makes employment adjustment more or less costly: as a consequence, the authors interpret the employment levels chosen by firms as a source of commitment. As far as quantity competition is concerned, Dewit et al. (2013) observe, similarly to our result, that the inflexible location is strategically more attractive than the flexible one: employment, acting as a source of commitment, enables the firm in the rigid country to attain a greater market share once production effectively takes place, to the detriment of the firm in the flexible country. Results are instead reversed when price competition is assumed, since strategic pricing by the firm in the flexible country harms the firm in the rigid location.[25]

Lu and Poddar (2006) set up a two-stage quantity competition game between a public and a private firm. Under demand uncertainty, the authors look at the decision to under or over invest in physical capacity as the outcome of strategic interaction. In their analysis, there is a symmetric result as long as demand is relatively high or low;[26] if instead demand realization is medium, there is an asymmetric outcome and the public firm, that is maximizing total welfare, is under investing in capacity, leaving a greater market share to the private firm, which is more efficient from a marginal cost point of view.

Besanko et al. (2010) embed the analysis of positive and negative capacity adjustments in a context of dynamic oligopolies. In their framework, two firms face two types of uncertainty: an exogenous one, related to the state of demand, and an endogenous one, reflecting strategic interaction and taking into account the rival's adjustment probability.[27] In their numerical analysis, multiple equilibria exist: at one extreme, one large firm would adapt its capacity to meet demand fluctuations, whereas at the other extreme only smaller firms would change their capacities, thus acting as swing producers.

3.3 THE MODEL

Under free trade,[28] global demand for the homogenous good x is represented by the following inverse linear expected demand function:

$$p = a - x + E(\varepsilon) \tag{17}$$

where ε is a demand additive[29] and exogenous shock, and $x = x_i + x_j$ is total output. The magnitude of the shock is ε in either states, but

25 In their framework, the effects of strategic pricing are ruled out if both firms choose the flexible country.

26 Both firms under invest for a high demand realization and they both over invest for a low demand realization.

27 Note that firms can only observe the rival's adjustment probability, not the adjustment in capacity itself.

28 We include this free-trade assumption to rule out any effect other than the impact of strategic interaction, demand uncertainty and cost asymmetries. Future research may include transport costs with differentiated products.

29 As in Spencer and Brander (1992) and Dewit et al. (2013).

it is positive in the good one and negative in the bad one, which occur with probability γ and $1-\gamma$ respectively.[30]

The expected value of ε is given by

$$E(\varepsilon) = \varepsilon(2\gamma - 1) \begin{cases} > 0 \iff \gamma \in \left(\frac{1}{2}, 1\right] \\ = 0 \iff \gamma = \frac{1}{2} \\ < 0 \iff \gamma \in \left[0, \frac{1}{2}\right) \end{cases} \tag{18}$$

In this framework, there are two factors of production: physical capacity, chosen in the first stage and sunk afterward,[31] and labour, which is fixed and is used in the second stage.[32]
In this baseline specification, factors are assumed to be substitutes, so that no particular labour requirement to install capacity, and vice versa, is introduced.[33]

Costs are exogenous: they are symmetric in the first stage (the unitary investment cost is c in both countries), and country specific in the second stage. In our framework, the second stage adjustment cost θ_i represents the country's degree of labour market regulation: in the good state, it reflects the overtime wage for producing beyond capacity, whereas in the bad state it represents the cost of keeping the plant idle and laying-off workers.[34] Hence, higher adjustment costs can be thought of as a proxy for more stringent labour regulations.

Total costs are given by

$$C(k_i, q_i) = ck_i^2 + \theta_i q_i \tag{19}$$

where k_i is the initial investment in physical capacity,[35] and q_i is the second stage output adjustment, either positive or negative. In the remaining of the section, we will assume that labour is more costly in country 1, that is:

Assumption A *In country* 1*, there is a more stringent labour regulation, so that second stage adjustment costs are greater in either state, with* $\theta_1 > \theta_2$ *for* $\forall x_1, x_2$ *and* $\forall \varepsilon$*.*

and so we will refer to country 1 (2) as the high-cost (low-cost) country. In this baseline specification, we also assume that positive and negative adjustments are equally costly, regardless of the adjustment sign. In an

30 Future work should also include a discrete distribution for $\varepsilon \in \left\{\varepsilon^{Bad}, 0, \varepsilon^{Good}\right\}$.

31 In the second stage, once demand has realized, capacity cannot be expanded or dismantled. In the bad state, firms can only keep the plant idle.

32 In this partial equilibrium analysis, the number of workers cannot change, and so firms cannot hire new workers in the good state.

33 In section 3.4, we introduce capacity-labor complementarity assuming that each installed unit of capacity requires a given endowment of labour to be fully operative.

34 In a previous version of this paper we also included asymmetric investment costs, c. For sake of interest, we decided to introduce asymmetries in the second stage only.

35 We can think of this investment as an output commitment chosen ex-ante by firms. In this framework, we consider a quadratic investment cost. We initially considered a CRS technology, but to no avail.

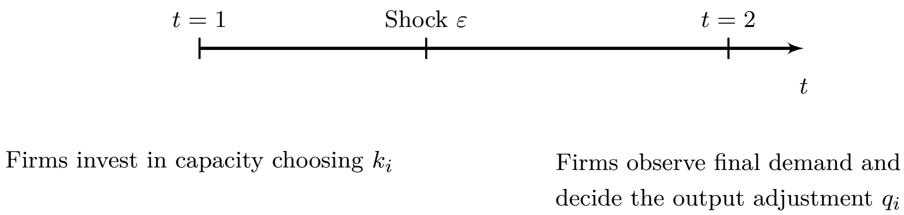


Figure 11: Timing of the model

extension to this model, we conjecture that negative adjustments, and thus lay-off costs, are more expensive,[36] and we evaluate the new impact of labour institutions on firms' output commitment. As displayed in Figure 11, this two-stage game is structured as follows: in the first stage, firms must choose their optimal level of physical capacity according to equation (17), that is, according to their expectations over final demand. Once uncertainty has resolved, firms observe final demand and eventually produce by playing Cournot competition: what they choose is the optimal level of adjustment q_i. Since labour is fixed and capital is sunk, firms choose these short-run output adjustments by adapting their labour endowments along the intensive margin: positive (negative) adjustments require in fact above (below) capacity production, which in turn requires overtime wages (lay-off schemes) as capacity cannot be increased (dismantled).

3.3.1 *Equilibrium analysis*

The model is solved through backward induction. Starting from the second stage, we derive the good and bad state optimal adjustments, solving[37]

$$\begin{aligned}
\max_{q_{i,g}} \pi_{i,g} &= (a + \varepsilon - (k_i + q_{i,g}) - x_{j,g})(k_i + q_{j,g}) - \theta_i q_{i,g} - c k_i^2 \\
\max_{q_{i,b}} \pi_{i,b} &= (a - |\varepsilon| - (k_i - |q_{i,b}|) - x_{j,b}))(k_i - |q_{i,b}|) - \theta_i q_{i,b} - c k_i^2
\end{aligned} \tag{20}$$

where $x_{j,g} = k_j + q_{j,g}$ and $x_{j,b} = k_j - |q_{j,b}|$. Good and bad state reaction functions are

$$\begin{aligned}
q_{i,g} &= \frac{a + \varepsilon - \theta_i - k_j - q_{j,g}}{2} - k_i \\
|q_{i,b}| &= k_i - \frac{k_j + |\varepsilon| - a - \theta_i - |q_{j,b}|}{2}
\end{aligned}$$

and equilibrium adjustments are

36 In line with the interpretation of EPL.
37 In case of a negative shock, the derivative with respect to q_i yields $-signum(q_i)((a + \theta_i - 2k_i - k_j + |\varepsilon| + 2|q_i| + |q_j|))$, but since $q_i < 0$ the $signum = -1$.

$$q^g_{i,g} = \frac{a + \varepsilon - 2\theta_i + \theta_j}{3} - k_i \quad (21)$$

$$|q^*_{i,b}| = k_i - \frac{\theta_j + |\varepsilon| - 2\theta_i - a}{3} \quad (22)$$

In the bad state, excess capacity is the gap between potential output and effective adjustment, that is $k_i - |q_i| = \frac{a + 2\theta_i - |\varepsilon| - \theta_j}{3}$, which is increasing in the adjustment cost θ_i.[38] Thus, an increase in θ_i increases the share of capacity that is idle, and ultimately contributes to the generation of excess capacity. This effect is in line with the empirical evidence in Chapter 4, of a positive link between EPL and capacity under-utilization.[39]

In this paper instead, we look at the impact of θ_i on the choice of k_i. Before the realization of demand, each firm maximizes its own expected profits, in anticipation of its optimal adjustments in either state, given by equation (22):

$$\max_{k_i} E(\pi_i) = \gamma E(\pi_{i,g}) + (1 - \gamma) E(\pi_{i,b}) \quad (23)$$

where $Prob(\varepsilon > 0) = \gamma$. The optimal investment in physical capacity is thus

$$k_i = \frac{\theta_i z}{2c} \quad (24)$$

where $z \equiv (2\gamma - 1)$. Recalling the expected value of ε from equation (18), we can distinguish these different cases:

1. If good and bad shocks are equivalently likely to occur, with $\gamma = 1/2$, then $E(\varepsilon) = 0$ and firms do not install any capacity, with $k_i = 0$: they rather wait for demand realization as they expect final demand to be equal to $p = a - x$;

2. If instead γ is sufficiently high, with $\gamma > 1/2$, then $E(\varepsilon) > 0$ and firms install capacity, with $k_i > 0$, and take their output commitment decision. In this case, they decide to move closer to $E(\varepsilon)$, but the firm in the high-cost country will move closer to minimize the impact of its greater future adjustment costs. In other words, $k_1 > k_2$ for $\theta_1 > \theta_2$;

38 In either state, adjustments negatively depend on the impact of labour costs. This is intuitive in the good state, with $\frac{\partial q_{i,g}}{\partial \theta_i} < 0$. In the bad state, since $q_{i,b}$ is in absolute values, the final effect is negative, after substituting the final level of capacity k_i: as labour costs increase, the adjustment is more and more negative. Hence during economic downturns, firms, in addition to overcapacity, will also experience lower production levels, in line with the predictions of Chapter 4.

39 Whereas this paper looks at the effect of EPL on the ex-ante investment decision, Chapter 4 looks at the effect of labour protection on the ex-post adjustment process, taking into account also the irreversibility of former investment decisions.

3. If instead $\gamma < 1/2$, firms have negative expectations over final demand, and do not accumulate any new capacity and wait for demand realization: this result does not imply firms' exit, rather it states that firms prefer to be totally flexible and incur only second stage adjustment costs.[40]

In this model, the shock hits the two countries symmetrically, and the two firms, when positive and negative adjustments are equally costly, will both solve the trade-off between commitment and flexibility in the same way.[41]
Proposition 1 summarizes these results:

Proposition 1 *In the baseline model, where positive and negative adjustment costs are equal to θ_i, with $\theta_1 > \theta_2$, both firms invest in capacity only if they expect with a sufficient probability an economic upturn. Moreover, firm 1, in the high cost country, invests more in physical capacity than firm 2, to minimize the impact of future adjustment costs, and may experience higher excess capacity during economic downturns.*

Proposition 1 also suggests that firms substitute labour with capacity when solving their trade-off between output commitment and output flexibility,[42] and explains that, within this framework, as labour costs increase, firms prefer output commitment. Throughout this section we will assume what follows:

Assumption B *The probability of a positive shock γ is large enough, with $\gamma \in (\frac{1}{2}, 1]$, so that firms always have positive expectations over final demand and eventually install some physical capacity.*

The 'no-capacity' scenario, with $\gamma = 1/2$ is described in 3.3.2.[43]

To conclude this section, we look at firms' profits, both ex-ante and ex-post, to assess under which conditions over-investment in capacity pays-off. In expectations, each firm gets

$$E(\pi_i) = \frac{1}{36c}[4c(a^2 + z) + 9z^2\theta_i^2 + 8acz(z\varepsilon - 2\theta_i + \theta_j)] \qquad (25)$$

and it is easy to show that, under Assumptions A and B, $E(\pi_1) > E(\pi_2)$ only if final demand is low, with

$$a + \varepsilon < \frac{(\theta_1 + \theta_2)(3z^2 + 4c)}{8cz}$$

40 Firms wait for demand realization and eventually produce in-house or outsource production.

41 The introduction of asymmetric demand shocks might imply mixed scenarios, with one firm choosing commitment and the other firm preferring total output flexibility.

42 As in Spencer and Brander (1992).

43 Future research should also include the consequences of negative expectations over former investment decisions: this analysis may require a dynamic model in which, at each stage, firms can destroy their already installed capacity depending on their expectations over final demand.

As a consequence, the rigid firm can exploit its greater investment in capacity and gain higher expected profits only if final demand is not too high, so only over a limited range of output values. If this is not the case, the other, more flexible firm adjusts more and gains higher expected profits.

To gain also an ex-post perspective, we look at profits after the resolution of uncertainty. Good state profits are represented by

$$\pi_i^g = \frac{4a^2c - 9(-2+z)z\theta_i^2 + 8ac\omega + 4c\omega^2}{36c}$$

with $\omega \equiv |\varepsilon| - 2\theta_i + \theta_j$. Again, we see that firm 1, in the high-cost country, gains higher good state profits as long as final demand is not too high, with

$$a + \varepsilon < \frac{(\theta_1 + \theta_2)(4 + 3z(2-z))}{8}$$

Bad state profits of firm i are given by

$$\pi_i^b = \frac{4a^2c - 9z(2+z)\theta_i^2 - 8ac\omega + 4c\omega^2}{36c}$$

which are positive only if initial investment costs are large enough, with $c > \dfrac{9z(2+z)\theta_i^2}{4(-a+\omega)^2}$.
In the bad state, the more committed firm can gain greater bad state profits only if final demand is large enough (that is, if the magnitude of the negative shock is not too large), with

$$a - |\varepsilon| > \frac{(\theta_1 + \theta_2)(4 - 6z - 3z^2)}{8}$$

If instead the drop in demand is large enough, the flexible firm will gain more. This result is more in line with the predictions of Cingano et al. (2010), where financially constrained firms invest less. In our framework, the realization of the bad state may act as a financial constraint on firms. To avoid incurring negative profits, firms prefer to under invest in capacity, as the excess of capacity may imply additional costs that in turn also increase the probability of bankruptcy.

Proposition 2 *In the baseline model, the more committed firm gains more, both ex-ante and ex-post, if the magnitude of the shock ε is not too large. In this way, the firm can gain from its higher initial commitment. If the magnitude of the shock is instead sufficiently large, the flexible firm, with lower second stage costs, can adjust more and achieve greater profits.*

As a last step, we compare firm i's profits in either states, that is:

$$\pi_{i,g} - \pi_{i,b} = \frac{9z\theta_i^2 + 4ac\omega}{9c}$$

with good state profits being greater than bad state profits for $\omega > 0$.

3.3.2 *Commitment vs. flexibility*

As previously discussed, firms invest in capacity only if they expect with sufficient probability an increase in final demand ($\varepsilon > 0$). Otherwise, firms do not exit but rather wait for demand realization and produce, either on their own or outsourcing, incurring only second stage costs. So, as long as $\gamma \in \left(0, \frac{1}{2}\right]$, $k_i = 0$ and firms' expected profits are

$$E(\pi_i)_{|k_i=0} = \frac{1}{9}((1-\gamma)(a - \varepsilon z - 2\theta_i + \theta_j)^2 +$$

$$\gamma(a + \varepsilon z - 2\theta_i + \theta_j)^2)$$

To understand how the trade-off between commitment and flexibility is solved, we compare expected profits with and without capacity:

$$E(\pi_i)_{|k_i>0} - E(\pi_i)_{|k_i=0} = \frac{9z^2\theta_i^2 + 16c(1-\gamma)(2\theta_i - \theta_j)(a - z\varepsilon)}{36c}$$

Recalling Assumption A, we must distinguish between firm 1 and 2. Firm 1 is better off under output commitment as long as the magnitude of the shock ε is small, with $|\varepsilon| < a/z$.[44] Interestingly, the trade-off for firm 2 depends also on the impact of cost asymmetries and on the relative labour cost differentials: if these are not so pronounced, and the two countries charge similar labour costs, output commitment decisions by the two firms are relatively similar, and so also firm 2 is better-off under output commitment. As the cost gap becomes more and more pronounced, installed capacities may differ substantially between the two firms, and firm 2 may be better-off under output flexibility. We can in fact distinguish these two cases:

1. Firm 2 is better off under output commitment if the shock is small (large), with $|\varepsilon| < a/z$ ($|\varepsilon| > a/z$), and if the cost asymmetries are not (are) pronounced, with $\theta_2 \in (\theta_1/2, \theta_1)$ ($\theta_2 \in (0, \theta_1/2)$);

2. If instead the shock is small (large) and cost asymmetries are (are not) pronounced, then firm 2 gains higher expected profits with no output commitment.

3.3.3 *Comparative statics*

We perform comparative statics on expected profits to assess how costs affect the ex-ante profitability of each firm. As far as the first stage cost c is concerned, the effect on expected profits is negative, with

$$\frac{\partial E(\pi_i)}{\partial c} = -\frac{\theta_i^2(-z)^2}{4c^2} < 0 \Longleftrightarrow \forall c, \theta_i, \gamma > 0$$

44 In line with Proposition 2

For both firms, higher investment costs imply in fact a lower level of capacity installation, which is detrimental to expected profitability as it leads to lower market shares. Obviously, the impact is less severe for the firm in the low-cost country.
The effect of θ_i on $E(\pi_i)$ is positive if final demand is not large enough, that is

$$\frac{\partial E(\pi_i)}{\partial \theta_i} > 0 \Leftrightarrow a + \varepsilon < \frac{9(z)^2\theta_i + 8c(2\theta_i - \theta_j)}{8cz}$$

That is, an increase in adjustment costs increases expected profitability, provided that final demand is not too large: firm 1 would in fact commit more, but the other firm, whose adjustment costs are lower and constant, may adjust more and satisfy a greater share of the market.
As a last step, we investigate the effect of an increase in the rival's adjustment costs on the ex-ante profitability of firm i. Interestingly, θ_j has a negative impact on $E(\pi_i)$, provided that θ_j is sufficiently small:

$$\frac{\partial E(\pi_i)}{\partial \theta_j} = \frac{2}{9}(z(a+\varepsilon) - 2\theta_i + \theta_j)$$

which is negative for $0 < \theta_j < 2\theta_i - z(a+\varepsilon)$. As θ_j increases up to a certain threshold, the output commitment of firm j increases, too, and the residual demand and expected profitability of firm i inevitably go down. This result confirms how firms strategically choose capacity to increase their expected market shares, at the expense of the rival firm.

These results combined explain that the impact of strategic interaction varies with the impact of cost asymmetries. Commitment k_i is increasing in the firm's own labour costs, and is unaffected by the rival's ones. Still, the consequences of commitment, in terms of expected profits, are increasing in the firm's own labour cost, and decreasing in the rival's one, provided that both final demand and θ_j are sufficiently small.

3.4 CAPACITY-LABOUR COMPLEMENTARITY

The baseline model predicts that, under factor substitutability, higher labour costs trigger over-investment in capacity. In this section, we consider an alternative cost specification that rather implies capacity-labour complementarity to assess whether a more complicated technology may alleviate the impact of labour costs and reduce excess capacity concerns:

$$C_i(k_i, q_i) = (c + h_i)k_i^2 + q_i(\theta_i + \phi h_i) \tag{26}$$

According to equation (26), capacity installation also requires a labour component, h_i, to be fully operative. This labour component also enters the second stage of production, magnified by the effect of a symmetric parameter $\phi \geq 1$ that captures investment irreversibility and affects unitary adjustment costs.[45] The new equilibrium level of capacity is:

$$k_i^{Complementarity} = \frac{z(\theta_i + \phi h_i)}{2(c + h_i)} \tag{27}$$

First of all, we want to compare Equation (27) with the baseline capacity,[46] and we observe that:

1. Interestingly, the h_i parameter does not affect this comparison;
2. $k_i^{Substitutability} > k_i^{Complementarity}$ if $\theta_i > c\phi$, that is, if the adjustment cost is greater than the investment cost, weighted by the irreversibility parameter.

As long as $\theta_i > c\phi$, we observe an additional effect: k_i is decreasing in h_i. As the factors of firm i become more complements, firm i reduces its capacity and prefers to stay more flexible:[47]

$$\frac{\partial k_i^{Complementarity}}{\partial h_i} = \frac{z(-\theta_i + c\phi)}{2(ch_i)^2} < 0 \Longleftrightarrow \theta_i > c\phi$$

Proposition 3 *Under factor complementarity, both firms are going to invest less in capacity than under the substitutability scenario, provided that $\theta_i > c\phi$, that is, provided that it is more costly to adjust output than to invest in capacity.*

Finally, we compare capacity decisions, under the complementarity assumption, of firm 1 and 2, and we observe that the firm in the high-cost country is, once more, going to install a higher level of capacity, with $k_1^c > k_2^c$, as long as

1. Either

$$\frac{\theta_1}{\theta_2} > \frac{h_1}{h_2} \tag{28}$$

2. or

$$\frac{\theta_1}{\theta_2} < \frac{h_1}{h_2}, \theta_1 > \theta_2, h_1 > h_2 \text{ and } c > \frac{\theta_2 h_1 - \theta_1 h_2}{(\theta_1 - \theta_2) + \phi(h_1 - h_2)} \tag{29}$$

45 In Chapter 4 the joint effect of labour market rigidity and capital irreversibility is taken into account. Also, the effect of an increase in labour rigidity on the accumulation of excess capacity is stronger in more capital intensive industries.

46 $k_i = \frac{z\theta_i}{2c}$

47 It is easy to show that, also in this new version, excess capacity during economic downturns is

$$\frac{1}{3}(a - \varepsilon + 2\theta_i - \theta_j + 2h_i\phi - h_2\phi)$$

which is increasing in both θ_i, as in the baseline model, and in factor complementarity, h_i.

In the baseline model, we observed that the condition $\theta_1 > \theta_2$ was sufficient to make firm 1 install more capacity. Here instead, the introduction of a sufficient degree of capacity-labour complementarity may alter the outcome. Firm 1 invests more if its relative adjustment cost is greater than its complementarity requirement, relatively to firm 2. If this condition does not hold, firm 1 invests more if the investment cost c is large enough, as in equation (29).[48]

3.5 SHOCK SPECIFIC ADJUSTMENT COSTS

In this section, we assume that it is more costly to make negative adjustments to capacity,[49] and we assess whether this assumption affect firms' behavior. To this purpose, we introduce two different cost structures: in the first one, in equation (30), we preserve our linear adjustment setting and let the distinction between good and bad state costs apply only to firm 2. This analysis stresses the relevance of cost asymmetries in the strategic interaction process and predicts that the firm incurring a more costly negative adjustment needs a greater γ to commit, and will also commit less. In the second approach instead, in equation (33), we want to understand firms' risk aversion by introducing quadratic adjustment costs (in the bad state only) in each firm's cost structure. The predictions of this specification are very similar to those of the baseline model.

3.5.1 *Negative and positive adjustment specific costs*

In this new specification, we let costs of firm 1 vary with the state of the world, with

$$C(k_1, q_1)_{|\varepsilon>0} = ck_1^2 + \beta q_1 \qquad C(k_1, q_1)_{|\varepsilon<0} = ck_1^2 + \theta_1 q_1 \tag{30}$$

with $\theta_1 > \beta$. The cost structure of firm 2 is $C(k_2, q_2) = ck_2^2 + \beta q_2$, regardless of the sign ε. The model is solved following the same approach of the baseline specification. The optimal investments in capacity are

$$k_1 = \frac{\gamma(\beta + \theta_1) - \theta_1}{2c} \qquad k_2 = \frac{\beta z}{2c} \tag{31}$$

As before, k_2 is positive only for $\gamma > \frac{1}{2}$; k_1 is positive for $\gamma > \frac{\theta_1}{\beta + \theta_1} > \frac{1}{2}$.[50] In this specification, firms' strategies are not symmetric: we could have a mixed scenario with one firm committing and the other one not.

48 If we assume that $h_1 = h_2 = h$, then we have, once again, $k_1 > k_2$ for $\theta_1 > \theta_2$.

49 It is in fact realistic to assume that it is more costly to fire than to pay overtime wages.

50 Given the greater negative adjustment cost, firm 2 needs a greater probability of a positive shock to invest.

Under this new assumption, we also have a different result with respect to the baseline model. Now, it is firm 2 that is going to invest more in capacity. Hence, the risk of incurring higher firing costs affects firm's behavior. We also look at the difference in firm 1's strategy: not only in this new context is firm 1 going to invest less than firm 2, but it is also going to invest less than its decision in the baseline specification:

$$k_1^{Baseline} - k_1^{extended} = \frac{\gamma(\theta_1 - \beta)}{2c}$$

which is positive, since we assumed $\theta_1 > \beta$. Hence, when negative adjustments are more costly, firms are going to invest less in capacity. They in fact prefer to wait for demand realization and eventually adjust. The baseline model predicts that over-investment in capacity pays-off in terms of expected profits. Once again, overcapacity pays-off if and only if the magnitude of the shock is not large enough: as the magnitude increases, the more flexible firm can gain more by adjusting more.

$$E(\pi_2) - E(\pi_1) > 0 \Leftrightarrow \varepsilon < \frac{8ac + (3 + 4c - 9\gamma)\beta + \theta_1(3 + 4c - 3\gamma)}{8cz}$$

Firm 2 also always achieves higher good state profits, but in the bad state, it does so if and only if final demand is relatively low, with $a - \varepsilon < \frac{3\gamma^2(\theta_1+3\beta)-(\theta_1+\beta)(3+4c)}{8c}$.

3.5.2 *Quadratic adjustment costs*

This analysis adds to the baseline cost specification a quadratic cost component that both firms must pay in case of negative adjustments. In this setting, firms face similar cost structures, but these vary with the realization of final demand, with

$$C(q_i, k_i)_{\varepsilon>0} = \theta_i q_i + c k_i^2 \quad (32)$$

$$C(q_i, k_i)_{\varepsilon<0} = \theta_i |q_i| + \alpha(k_i - |q_i|)^2 + c k_i^2 \quad (33)$$

where $\alpha(k_i - |q_i|)^2$ is the component related to the distance between potential and actual output. The optimal level of physical capacity is the same of the baseline model:

$$k_i = \frac{\theta_i z}{2c}$$

That is, despite the quadratic adjustment cost, capacity is going to be installed if and only if $Prob(\varepsilon > 0) > \frac{1}{2}$. To extend our analysis, we look at the impact of quadratic adjustment costs on the ex-ante and ex-post profitability, and results are in line with Proposition 2.

3.6 CONCLUSIONS

This paper contributes to the quantity competition literature by relating firms' investment decisions, in terms of physical capacity, to the institutional background in which firms operate.

To do this, we set up a two-stage game with demand uncertainty where firms initially install capacity according to expected demand, and adjust their output levels once demand has realized. In this model, there are two factors of production: physical capacity and labour, needed to adjust production targets. We introduce second stage cost asymmetries by formalizing different institutional regimes, meant as rigid or flexible labour markets, to assess their impact on capacity building.

This model predicts that firms install capacity only if they have positive expectations over final demand; if expectations are instead neutral or negative, they do not commit at all and wait for demand realization. Positive investments in capacity allow firms to move closer to their expectations, and the firm facing higher adjustment costs moves even closer, so as to minimize the impact of future adjustment costs. Hence, the firm in the high-cost country has an additional incentive to invest more in physical capacity, potentially to the detriment of the more flexible firm: if in fact the magnitude of the shock is not too large, larger commitment pays-off in terms of greater profitability.

To assess whether these results stem from the assumption of perfect substitutability between capacity and labour, we consider an alternative cost specification with capacity-labour complementarities. Provided that adjustment costs are greater than installation costs, when factors are complements, both firms choose to invest less in capacity than before.

This model does not account for the social implications of excess capacity. Future research should thus include a welfare point of view and derive the socially optimal level of physical capacity. The capacity chosen by a Social Planner would then be compared with what observed in this paper, and with the level agreed upon by two colluding firms. Also, future work should entail the analysis of Mergers and Acquisitions (M&A) and the reallocation of existing capacity.

Last but not least, demand uncertainty and firms' investment decisions could be embedded in the framework of collective wage bargaining: rather then choosing investment levels, firms can in fact commit also by choosing their optimal labour endowment. Following the approach of Dhillon and Petrakis (2002), we could consider a wage bargaining setting under demand uncertainty to see whether the bargaining process and the resulting wage are affected by firms' inability to predict final demand.

4

THE IMPACT OF EMPLOYMENT PROTECTION AND INVESTMENT IRREVERSIBILITY ON EXCESS CAPACITY

Abstract

Exploiting a country-sector panel of European firms, we estimate the joint effect of labour protection and capital irreversibility on the excess of physical capacity, meant as the share of installed capacity that is not exploited by firms.
We observe that an increase in the protection of regular workers raises excess capacity, and this effect is stronger in sectors where capital is more irreversible.
Our result is robust to the estimation of a diff-in-diff analysis: we observe that countries experiencing a toughening of labour restrictions also tend to experience higher excess capacity in the long run.

Keywords: Industrial organization, Labour economics

JEL Classification: J, L.

4.1 INTRODUCTION

Excess capacity reports the deviation of actual output from what could be potentially achieved by an economic system or by a production unit. The first analysis on excess capacity date back to the late 1970s; still, excess capacity became, once again, a major concern after the 2009 financial turmoil. The credit crunch and the inevitable fall in consumption levels revealed in fact how exposed the real side of an economy is to the financial one, and, fore and foremost, how these two elements are so deeply related. Macroeconomists recently started looking at the effect of the financial cycle on the creation and destruction of potential output,[1] that is, the maximum volume of production a given economy can achieve.[2] On the theoretical side, many works blamed strategic interaction and demand uncertainty as responsible for the rise in overcapacity.[3]

1 At the aggregate level.
2 See, for instance, Furceri and Mourougane (2012), Bijapur (2012), and Benati (2012).
3 See, among others, Spence (1977) and Dixit (1979). For a more detailed overview of the existing literature, see Chapter 2.

Figure 12 reports potential output and output gap[4] for a sample of European manufacturing industries.[5] Negative output gaps account for excess capacity, with actual production falling well below potential output, and the output gap for the countries considered has been persistently negative since 2008.

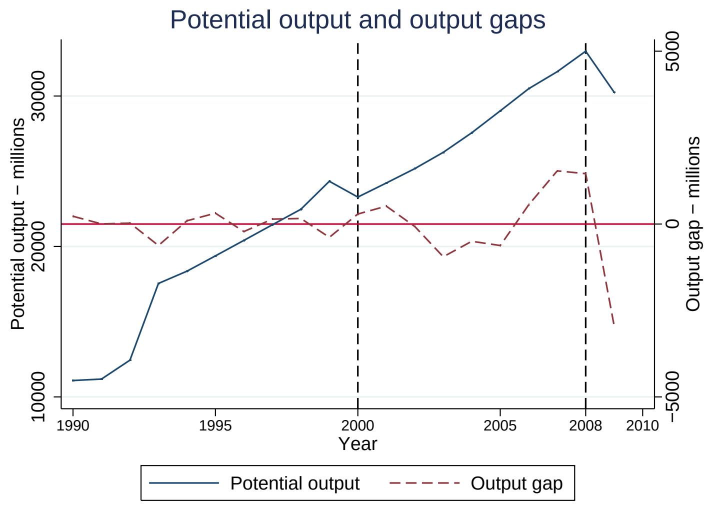


Figure 12: Potential output and output gaps

Table 3 suggests that also a capital intensive industry, such as the Automotive one, is not exempted from negative output gaps and excess capacity: in some countries the CU[6] rate dropped sharply. In Italy, for instance, the average plant CU rate fell from 78% to 54% in less than five years, whereas in the United Kingdom and in Germany it was stable at 92% and 90% respectively.[7] Hence, Table 3 suggests the presence of some country-specific factors that may explain different investment decisions and capacity exploitation rates.
Available evidence mainly investigates excess capacity at the aggregate level. To distinguish our work, we adopt a more fragmented approach and focus on excess capacity at the country-sector level to understand which sectors, in which countries, tend to experience higher excess capacity. Are firms too myopic when setting up their production facilities, or are there any other factors that make them invest too much in physical capacity? Also, why do firms react so differently, in terms of output adjustments, to a demand volatility?

4 Potential output is the maximum volume of production that can be achieved for given input factors and prices, whereas actual output represents the business cycle, and is defined as the difference between potential and actual production volumes.
5 This data come from the OECD Stan Database. Countries included are: Austria, Belgium, Czech Republic, Denmark, Estonia, Finland, France, Greece, Italy, Luxembourg, Slovenia, and Sweden, from 1990 to 2009. To retrieve potential output, we dropped missing values and applied the HP-filter, for annual data, to the volume of production, in million units.
6 Defined as the ratio between actual and potential output.
7 From Il Sole 24 ore.

Country	CU 2007	CU 2011	CU 2012	Total capacity
Germany	89%	89%	90%	6.4 million
France	74%	67%	60%	3.3 million
Spain	86%	79%	70%	3.0 million
Russia	72%	69%	70%	2.7 million
United Kingdom	93%	87%	92%	1.6 million
Italy	78%	53%	54%	1.4 million
Turkey	90%	79%	68%	1.4 million
Poland	95%	86%	70%	1.2 million
Czech Republic	90%	92%	84%	6.4 million

Table 3: Actual and output production,
European Automotive Industry

The theoretical framework developed in Chapter 3 identifies a new explanation for excess capacity, and explains, with an *ex-ante perspective*, the impact of labour restrictions on firms' irreversible investment decisions, and shows that firms in rigid labour markets tend to invest more in physical capacity,[8] thus running the risk of incurring overcapacity during economic downturns. This model also shows, in line with the empirical findings of this Chapter, that the gap between actual and potential output is increasing in labour costs.

This empirical Chapter extends this framework and estimates the impact of EPL,[9] on the short-run excess capacity, proxied by the share on unexploited physical capacity,[10] to predict the *ex-post consequences* of labour protection on firms' short-run output adjustments.

Cingano et al. (2010) condense this interpretation: "Typically, the presence of dismissal costs raises firms' adjustments costs. For this reason firms may have incentives to distort their production choices toward the more flexible input, thus substituting labour for capital". This statement confirms the theoretical results, and illustrates the transmission channel that impacts both output adjustments and capacity underutilization rates. In light of this statement, and given the theoretical foundation, we expect excess capacity to be increasing in the level of EPL.

Cunat and Melitz (2012) provide an alternative description of the consequences of labour protection, as labour market rigidities impede

8 This result is also due to strategic interaction, in line with the Industrial Organization literature: firms over invest in capacity, and thus commit to a higher level of output to gain a higher market share.

9 The OECD measure for EPL substantially measures firing costs and procedures, for both individual and collective dismissals. This measure only partially captures the degree of labour rigidity: hence, future analysis should also include alternative indicators, such as minimum wage policies.

10 Obtained from the CU rate.

the reallocation of workers toward their most efficient use. This additional constraint may consequently affect factor productivity and may lead to a sub-optimal rate of CU.

Throughout this paper, we consider the joint effect of EPL, an exogenous constraint at the country-level, and capital intensity, an endogenous constraint reflecting the sectoral sunkness and irreversibility of former capacity decisions. As stressed by Pindyck (1988), irreversibility is an industry-specific characteristic: "Irreversibility usually arises because capital is industry- or firm-specific, that is, it cannot be used in a different industry or by a different firm. A steel plant, for example, is industry-specific. It can only be used to produce steel, so if the demand for steel falls, the market value of the plant will fall. Although the plant could be sold to another steel company, there is likely to be little gain from doing so, so the investment in the plant must be viewed as a sunk cost". In light of this statement, we expect a stronger effect of EPL in sectors with more irreversible investment decisions. Figure 13 reports the deviation of actual from potential output of the most and least capital intensive manufacturing industries,[11] and shows how the two capital intensive industries considered, namely the chemicals and motor industries, tend to be affected by more volatile business cycles.

To disentangle the effect of EPL, we distinguish between total restrictions, restrictions on temporary and regular workers. As far as capital sunkness is concerned, we use the time invariant capital intensity of the corresponding US manufacturing industry, following the approach of Rajan and Zingales (1998).

The impact of EPL on excess capacity is somehow ambiguous, as its sign depends on the type of protection considered: the effect of total EPL is negative, but this is mainly driven by the protection on temporary workers. More interestingly, our estimates predict that the effect of regular worker protection is detrimental to excess capacity, a result which is aligned to the predictions of Chapter 3. The opposed effects of these two type of protections reveal different capacity-labour complementarities between skilled-unskilled (regular-temporary) workers and capital.[12] The marginal effect of EPL is instead unambiguous:

11 In this stylized fact analysis, we use the OECD Stan Database. Capital intensity is defined as the ratio between the formation of capital (volume) and total employment, for the countries above mentioned. The industries included in the Stan Database are classified at the ISIC Rev.3 2 digit level, and include: Food products and beverages; Tobacco products; Textiles; Wearing apparel, dressing and dyeing of fur; Leather, leather products and footwear; Wood and products of wood and cork; Pulp, paper and paper products; Printing and publishing; Coke, refined petroleum products and nuclear fuel; Chemicals and chemical products; Rubber and plastics products; Other non-metallic mineral products; Basic metals; Fabricated metal products, except machinery and equipment; Machinery and equipment, n.e.c.; Office, accounting and computing machinery; Electrical machinery and apparatus, n.e.c.; Radio, television and communication equipment; Medical, precision and optical instruments; Motor vehicles, trailers and semi-trailers; Other transport equipment; Manufacturing n.e.c..

12 Protection of regular workers increases excess capacity, since firms will hire less workers to avoid additional dismissal costs. But with a lower workforce, firms can exploit

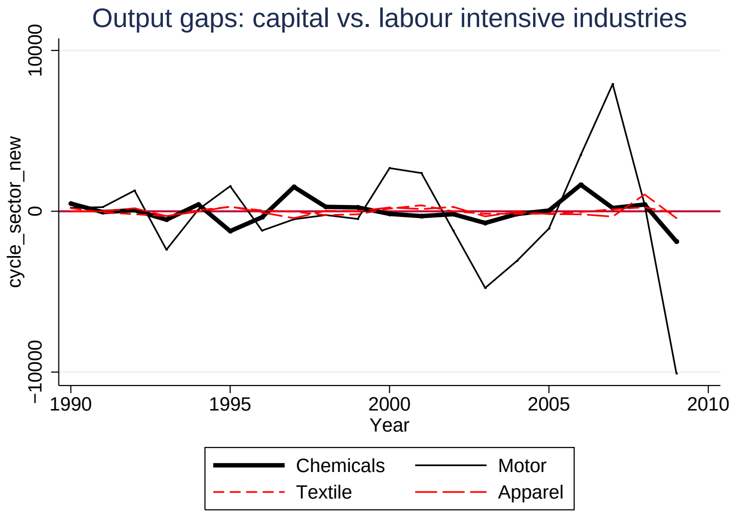


Figure 13: Excess capacity: capital vs. labour intensive labour industries

an increase in labour protection is more detrimental, in terms of excess capacity, to capital intensive industries.[13]

Our results are robust to the estimation of a diff-in-diff analysis: we observe that countries experiencing a toughening of labour restrictions also tend to experience higher excess capacity over time.

This work is structured as follows: Section 4.2 describes the related literature, Section 4.3 describes the empirical strategy and the sample structure, Section 4.4 shows the main results and predictions, Section 4.5 reports some robustness analysis, that also include a difference-in-difference regression specification, and Section 4.6 draws the main conclusions and potential policy implications.

4.2 LITERATURE REVIEW

The existing literature on excess capacity is mainly theoretical. The seminal contributions by Spence (1977) and Dixit (1979) identify ex-

less their physical capacity, and this effect is more severe for industries with more irreversible investments. Instead, as the protection of temporary workers increases, excess capacity tends to go down. This phenomenon can be explained as follows: as EPL on temporary workers increases, firms will employ less atypical workers and will substitute them with regular, permanent workers, with positive repercussions on CU.

13 As an extension to the main analysis, we investigate the relation between excess capacity and demand uncertainty. More specifically, we look at which industries, in terms of demand fluctuations, suffer more from an increase in employment protection and we find that an increase in the protection of temporary workers is more detrimental, with respect to excess capacity, in industries facing a higher demand volatility, where a flexible re-allocation of resources is crucial. We also consider the role of capital intensity in the alleviation of demand-related risk, and find that demand fluctuations are more effectively offset in more capital intensive industries. Results are reported in Annex A.2.3.

cess capacity as the result of strategic interaction: incumbents install more physical capacity and commit more to gain higher market shares and deter entry. A similar interpretation for excess capacity has been provided by models including stochastic demands and mixed duopolies.

Within the theoretical literature, Chapter 3 provides a new explanation for excess capacity. Firms in two different countries install capacity under demand uncertainty, and adjust their production levels using labour once final demand has realized.[14] In this context, labour regulation affects firms' cost structures, and more or less flexible labour markets lead to lower or higher adjustment costs. These country-level asymmetries ultimately affect firms' capacity decisions by making firms substitute differently between capacity and labour. More specifically, there is overcapacity in the country where labour is more rigid and labour adjustments more costly. Also Dewit et al. (2013) investigate the link between labour institutions and excessive commitment, with respect to a given employment level. Firms' choice is affected by the country level of employment protection, and the authors show that, under quantity competition, the rigid location is preferred.

On the empirical side, the approach has generally focused on the assessment and measurement of capacity and CU,[15] or on its role in business cycles,[16] as reported in Chapter 2.

To the best of our knowledge, there are no applied works that look at the impact of employment protection on the rise of over capacity. The existing literature has in fact analyzed the impact of EPL on other relevant elements of firm dimension, such as factor productivity, capital investment decisions and the capital-labour ratio. Hopenhayn and Rogerson (1993) consider the impact of firing restrictions on the reallocation of resources and conclude that more stringent restrictions impede firms to freely move workers, and resources, towards their most efficient use and eventually have a negative effect on labour productivity. Also Saint-Paul (2002) confirms the existence of a negative link between EPL and firm's productivity: by investigating the effect of firing restrictions on innovation, the author explains that this source of rigidity makes firms prefer secondary, and safer, innovation on existing products over primary, and riskier, innovation on new products. Moreover, Bassanini et al. (2009) study the relation between EPL and TFP, identifying a lower growth rate in countries with a more binding labour legislation.

Still, Belot et al. (2007), and Lagos (2006) show that, under some circumstances, EPL can ultimately have a positive impact on labour productivity. More precisely, according to Belot et al. (2007), firms facing workers' dismissal protection might have more incentives to invest in firm specific human capital, but this result holds as long as EPL is suf-

14 Ex-post adjustments can be either positive or negative, depending on final demand.
15 See, for instance, Nelson (1989) and Berndt and Hesse (1986).
16 See, for instance, Hansen and Prescott (2005).

ficiently low. Under Lagos (2006), an increase in the reservation wage, under stringent EPL, can induce a more selective employee-employer matching process, with positive spillovers on overall productivity.

The EPL literature has devoted consistent attention also to labour market dynamics, linking the effects of labour legislation to a lower job turnover rate. These results are confirmed by Autor et al. (2007) and Kugler and Pica (2008), who respectively look at job turnover rates of American and Italian firms. Also, Micco and Pages (2006) show that a more stringent regulation implies a significant drop in turnover, with even stronger consequences in sectors with high demand volatility. Haltiwanger et al. (2006) predict instead a more severe impact of EPL in industries with high job reallocation needs.

Last but not least, Bertola (2004) and Koeniger and Leonardi (2007) analyze the effect of labour market regulation of firms' investment decisions. Whereas the former work traces the reduction in the optimal investment level back to the hold-up problem, the latter explains that EPL, by increasing labour costs, encourages the adoption of more capital intensive technology. On the other hand, Cingano et al. (2010) identify a negative link between EPL and the capital-labour ratio, concluding that dismissal restrictions negatively affect investment, capital and value-added per-workers, with a more dramatic impact in sectors with high job reallocation needs.

4.3 RESEARCH METHOD AND DATA

4.3.1 *Empirical strategy*

In this paper, we measure excess capacity with the share of physical capacity that is not used by a given sector, in a given country, at a given year. Then, to evaluate the effect of EPL we consider independently its sub-specifications:[17]

1. Total EPL;
2. Individual dismissal of workers with regular contracts;
3. Regulation of temporary contracts.

These three different measures are defined only at the country level and do not capture essential sector characteristics, such as the irreversibility of investments. This is why we match the level of EPL with the sector specific level of capital intensity and estimate the joint impact of these two constraints on the rise of excess capacity. To overcome potential endogeneity issues, we follow the seminal approach of Rajan and Zingales (1998) and use the time invariant level of capital intensity of the

17 See Venn (2009). We exclude from the analysis of collective dismissal regulations: first of all, because of its limited data availability. Then, this index reports the additional restrictions to be respected in case of massive lay-offs, and the interpretation of the results may be misleading.

corresponding US manufacturing industry.

To predict this relation, we estimate the following equation:

$$EC_{jct} = \beta_1 + \beta_2 EPL^i_{ct} + \beta_3 K/L^{USA}_j + \beta_4 EPL^i_{ct} * K/L^{USA} + \\ + \beta_4 (X_{jct}) + \mu_j + \mu_c + \mu_{jt} + \mu_{ct} + \mu_{cj} + \varepsilon_{jct} \quad (34)$$

where EC_{jct} is the excess capacity in sector j, country c, year t, EPL^i_{ct} is the country-year level of Employment Protection,[18] K/L^{USA} is the time invariant level of capital intensity in the United States, for sector j, X_{jct} is a matrix of other country sector information, $\mu_j, \mu_c, \mu_{jt}, \mu_{ct}, \mu_{cj}$ are respectively sector, country, sector/year, country/year and country/sector fixed effects and ε_{jct} is the residual.

4.3.2 *Data*

To investigate the effects of labour market rigidity on the rise of excess capacity, we exploit the following data sources:

1. The Business and Consumer Survey (BCS), that gathers CU rates for European industries;[19]

2. The OECD Employment Protection Labour index;

3. The INDSTAT2 2013 Unido database, providing industry specific information.

The BCS[20] provides quarterly and monthly time series information, collecting harmonized answers to questions[21] concerning the plant operating status, mainly regarding the CU rate.[22] This information is available for 27 European countries and 21 sectors[23] from 1990 to 2010.

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18 Where i denotes the different EPL classifications: total EPL, EPL on regular workers, and EPL on temporary workers.

19 To the best of our knowledge, this CU rate has only been introduced by Planas et al. (2010) to assess the link between output gap fluctuations and TFP.

20 Available at http://ec.europa.eu/economy_finance/db_indicators/surveys/time_series/index_en.htm

21 Quarterly questions are: factors limiting production, assessment of current production capacity, the duration of production assured by current order-book levels, new orders in recent months, export expectations for the months ahead, current level of CU, competitive position in the domestic market, competitive position inside and outside the EU. Monthly questions are instead: business confidence indicator, the production trend observed in recent month, assessment of order-book levels, assessment of export order-book levels, assessment of stocks of finished products, production expectations for the months ahead, selling price expectations for the months ahead and employment expectations for the months ahead.

22 Data are collected and gathered by the country Statics Offices. Annex A.2.2 summarizes the collection and harmonization methodology for the countries included in the sample.

23 Nace 1.1 classification, 4−digit level.

From the assessment of the current CU rate, we retrieve our proxy for excess capacity:

$$\text{Excess of capacity}_{jct} = 100 - \text{capacity utilization rate}_{jct}.$$

The OECD EPL database[24] contains information for 40 different countries, covering the period 1985-2008. This data source provides measures for total labour market rigidity according to three different classifications: rigidity of regular employment, rigidity of temporary employment and rigidity of collective employment. The measurement for protection on temporary and regular workers is available throughout the whole period considered. All these three indicators can vary from $0-6$, where 0 represents the least restricted legislation and 6 the most restricted one.[25]

The measure of US capital intensity is retrieved from the Unido Indstat2 2013 revision and is defined as the ratio between gross fixed capital formations, in $, and the number of workers. We also gather a measure of value added, at the country-sector level, to control for potential changes in our dependent variable that can be traced back to changes in final demand.[26] From the Unido database we retrieve other industry information, such as the wage compensation and the number of plants, used as additional controls.[27]

The final panel consists of 21 European countries and 21 manufacturing industries, classified at the Nace 1.1 Revision at the 2-digit level, from 1990 to 2008. In total we have approximately 5500 observations[28] and 441 country-sector observations.[29]

4.3.3 *Descriptive statistics*

Table 4 reports the summary statics for the main variables of interest. The average share of under-exploited capacity is approximately one fifth of overall physical capacity, or the 20% of existing capacity. On average, the normalized sector US capital intensity is relatively low: in 1990, at the beginning of our sample, the average capital intensity was 0.17, whereas the sample-average is 0.1 and the average annual value is 0.044. As far as labour indicators are concerned, all the reported

24 Available at www.oecd.org/employment/emp/oecdindicatorsofemploymentprotection.htm#data

25 For more information on the methodology: www.oecd.org/els/emp/EPL-Methodology.pdf

26 We also controlled for a standardized measure of GDP, only available at the country level, but opted for a more specific level of analysis as changes in demand might not be symmetric within countries.

27 For instance, the number of plants allows us to control for changes in the excess of capacity due to plant turnover, whereas the ratio between the number of plants and the number of employees gives us an approximate estimate of the plant size.

28 The panel is unbalanced.

29 For a detailed list of countries and sectors included in the analysis see Annex A.2.1.

averages, with the exception of collective lay-off restrictions, are slightly above 2. Figure 14 plots the countries included in the sample according to their average level of EPL over the period considered.[30]

Variable	Mean	Std. Dev.	Min	Max.
Excess capacity	19.044	7.292	0.075	90.925
EPL_Total	2.237	0.863	0.6	4.1
EPL_Temporary	2.132	1.39	0.25	5.38
EPL_Regular	2.347	0.777	0.950	4.83
EPL_Collective	3.243	0.729	1.88	4.88
1990 US capital intensity	0.172	0.196	0	1
average capital intensity	0.101	0.16	0	1
annual capital intensity	0.044	0.077	0	1

Table 4: Summary statistics

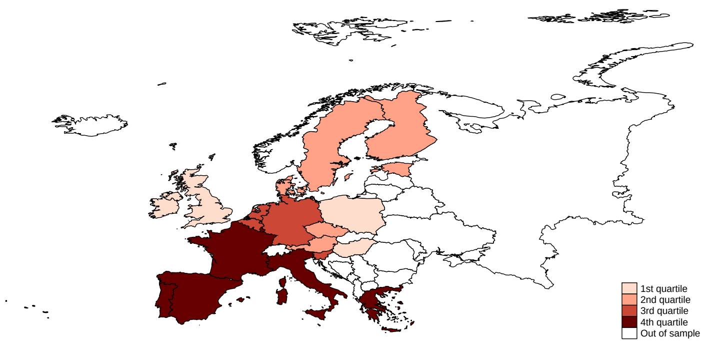

Figure 14: Average EPL, 1990-2008

Table 5 reports the correlation coefficients, at the 1% statistical significance, for the main variables used in the estimation process. Clearly, all the four measures of employment protection are significantly correlated. Interestingly, the measure for collective dismissal is negatively correlated with the two other classifications of EPL. Excess capacity is negatively correlated with total EPL[31] and EPL on regular workers, but the coefficient is positive with respect to collective dismissals and the protection of temporary workers.

4.4 RESULTS

As a preliminary analysis, we estimate the impact of the different classifications of EPL on the rise of excess capacity, without taking into

30 Country averages are classified in quartiles: the first quartile is from 0.66 to 1.73, the second quartile ranges from 1.73 to 2.23, the third quartile from 2.23 to 2.69 and the fourth quartile from 2.69 up to 3.63

31 Although the correlation magnitude is negligible.

	Exc_cap	Total	Regular	Collective	Temporary
Exc_cap	1				
EPL Total	−0.05*	1			
EPL Regular	−0.15*	0.62*	1		
EPL Collective	0.16*	−0.07*	−0.26*	1	
EPL Temporary	0.02	0.90*	0.20*	0.07*	1

* significant at 1%.

Table 5: Correlations

account the sectoral degree of investment irreversibility. To this purpose, we look at the effect of the EPL classifications alone and together. Results are reported in Table 6. Specification (1) reports the joint effect of all the EPL measures,[32] whereas specifications (2)-(4) look at their individual effects.[33] When jointly considered, all the measures, expect for total EPL, have a positive and significant impact on the accumulation of excess capacity.[34] Still, results change when considering the effects separately, and the only significant effect stems from collective measures.

To further disentangle the effect of these measures, we concentrate on one classification of EPL at a time and look at its impact on excess capacity.

4.4.1 *Total EPL*

Table 7 reports the effect of total EPL, without distinguishing between its sub-classifications. Specifications (1) and (2) interact it with the US capital intensity in 1990, specifications (3) and (4) with the US average capital intensity. In each specification, we control for final demand, as measured by the sector-country value added, and for changes in the underlying market structure, reflected by the change in the number of plants. The effect of EPL alone is negative, and this direction is mainly driven by the effect of the protection of temporary workers.[35] Still, we observe that the sign of the interaction term is positive: as EPL increases, more capital intensive industries will tend to experience a higher level of excess capacity,[36] as displayed in Figure 15.

To have a closer look at the joint effect of the two considered constraints, we evaluate the marginal effect of total EPL along the whole

32 Also including the effect of the additional restrictions for massive lay-offs.
33 The change in the number of observations is due to the limited availability of information on additional collective dismissal procedures.
34 The effect of EPL on regular and temporary workers is significant at 10.1%.
35 See Table 9.
36 The regressors for capital intensity have been omitted as time invariant.

Excess capacity	(1)	(2)	(3)	(4)	(5)
EP_overall	-10.794*	-0.561			
	(6.441)	(0.454)			
EP_collective	0.424***		4.338***		
	(0.112)		(1.090)		
EP_temporary	5.244			-0.326	
	(3.232)			(0.237)	
EP_regular	5.279				0.680
	(3.258)				(0.739)
Country FE	Yes	Yes	Yes	Yes	Yes
Sector FE	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes
R^2	0.087	0.077	0.072	0.077	0.076
N	3836	5560	3836	5560	5560

* significant at 10%; ** significant at 5%; *** significant at 1%

Standard errors clustered at the country-sector level in parentheses.

In Specification (1) we performed the regression on the square root of excess capacity.

Table 6: Effect of EPL

distribution of capital intensity.[37] More precisely, from equation (34), we estimate the following linear marginal effect for each dimension of EPL:

$$\text{marginal effect of EPL} = \beta_2 + \beta_4 K/L_j^p, \tag{35}$$

where K/L_j^p denotes the value of the capital intensity variable at percentile p. Figure 15 represents the marginal effect for total EPL, which is is increasing in the level of capital intensity and becomes positive after a certain threshold. This trend is confirmed by the separate estimations that include EPL on regular and temporary workers, respectively in Tables 8 and 9.[38]

37 Since the variable refers to one country only and it is time invariant, it has a discrete distribution over the normalized interval $(0, 1)$. Given the limited number of observations available, when computing the marginal effect we generate a fictitious distribution for the reclassified capital intensity: starting from its minimum realization, we increase it by an additional 0.01 at each iteration, up to the original maximum realization.

38 In a separate analysis, we look at the impact of EPL on capital intensity, which, in our framework, is defined as the capital-labour ratio. Our results are in line with the predictions of Cingano et al. (2010) of a negative link between these two variables. Still, this evidence is not against the predictions of Chapter 3, where we were rather looking at the impact of EPL on the accumulation of potential output.

Excess capacity	(1)	(2)	(3)	(4)
EP_overall	-4.195**	-0.996	-4.935**	-3.923**
	(1.842)	(1.763)	(2.104)	(1.975)
1990 K/L	0.000	0.000		
	(.)	(.)		
Interaction 1	4.564**	4.848**		
	(1.964)	(2.358)		
Average K/L			0.000	0.000
			(.)	(.)
Interaction 2			3.514	4.956
			(2.758)	(3.091)
Value added		0.000		0.000
		(0.000)		(0.000)
Change # plants		-0.003		-0.007
		(0.004)		(0.006)
Country FE	Yes	Yes	Yes	Yes
Sector FE	Yes	Yes	Yes	Yes
Country-Sector FE	Yes	Yes	Yes	Yes
Year-Sector FE	Yes	Yes	Yes	Yes
Year-Country FE	Yes	Yes	Yes	Yes
R^2	0.342	0.368	0.297	0.325
N	4622	3686	5560	4352

1990 and average capital intensities are constant over time and have been omitted

* significant at 10%; ** significant at 5%; *** significant at 1%

Standard errors clustered at the country-sector level.

Table 7: Total EPL

4.4.2 *Protection of regular workers*

Table 8 reports the effect of the protection on regular workers, and follows the same construction of Table 7. This type of protection has a positive, though not always significant, impact on excess capacity. Moreover, the interaction term is positive,[39] confirming the pattern observed above: more capital intensive industries, with a more severe investment irreversibility, suffer more from an increase in regular worker protection. The marginal effect of EPL on regular workers is displayed in Figure 16: it positive, and increasing, for any level of capital intensity.

Labour intensive industries are affected only by the exogenous con-

39 Although it is significant only when it involves the average capital intensity in specification (3).

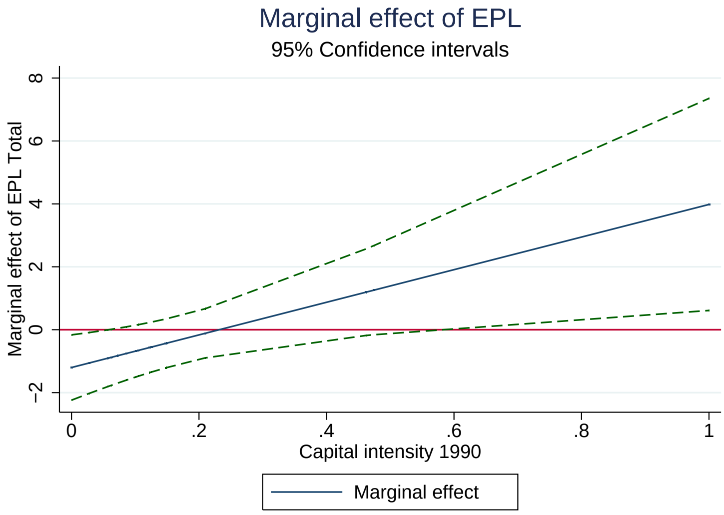

Figure 15: Marginal effect of Total EPL
on 1990 US Capital Intensity

straint on labour protection, and will reduce their labour force following an increase in EPL, and the absence of sunk costs prevents them from accumulating excess capacity. Capital intensive industries face instead an additional constraint, that stems from the irreversibility of former investment decisions: as EPL increases, they not only reduce their labour force, but they may also sub-optimally exploit their installed capacity and experience overcapacity during economic downturns. The complementarity between capital and skilled labour, or senior workers, observed by Janiak and Wasmer (2012) may then explain this trend.

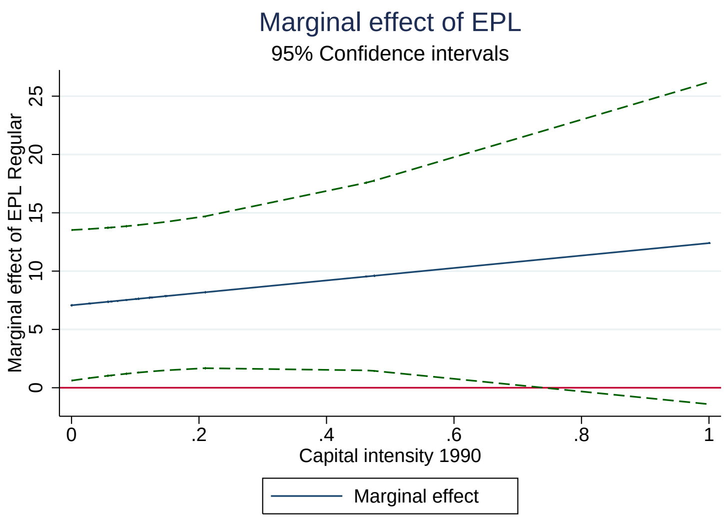

Figure 16: Marginal effect of EPL Regular
on 1990 US Capital Intensity

Excess of capacity	(1)	(2)	(3)	(4)
EP_regular	4.357***	4.023*	3.660	-1.441
	(1.572)	(2.284)	(3.519)	(2.081)
1990 K/L	0.000	0.000		
	(.)	(.)		
Interaction 1	5.331	1.438		
	(6.927)	(6.273)		
Average K/L			0.000	0.000
			(.)	(.)
Interaction 2			16.889*	13.528
			(8.999)	(8.370)
Value added		0.000		0.000
		(0.000)		(0.000)
Change # plants		-0.002		-0.006
		(0.004)		(0.006)
Country FE	Yes	Yes	Yes	Yes
Sector FE	Yes	Yes	Yes	Yes
Country-sector FE	Yes	Yes	Yes	Yes
Year-sector FE	Yes	Yes	Yes	Yes
Year-country FE	Yes	Yes	Yes	Yes
R^2	0.340	0.366	0.298	0.325
N	4622	3686	5560	4352

1990 and average capital intensities are constant over time and have been omitted

* significant at 10%; ** significant at 5%; *** significant at 1%

Standard errors clustered at the country-sector level.

Table 8: Protection of regular workers

4.4.3 *Protection of temporary workers*

As a last step, we perform the analogous analysis for the protection of temporary workers. Results are reported in Table 9. Contrary to what observed so far, an increase in the protection of atypical workers reduces excess capacity. As temporary workers become more and more protected, firms tend to replace them with regular labour. In fact, the correlation between this type of protection and employment is positive and significant, as reported in Table 5.[40] As previously discussed, the complementarity between regular workers and capital explains why more regular workers contribute to a better CU rate and reduce excess

40 The 0.08 correlation coefficient is significant a 1%. Also, employment is negatively correlated with excess capacity: −0.0264 at the 10% significance.

capacity. Still, Table 5 shows an additional effect: an increase in the protection of temporary labour is significantly correlated with a 0.2 increase in the protection of regular workers. This effect explains the positive sign of the interaction term in the regression output. The increase in EPL for regular workers partially offsets the better exploitation of physical capacity and makes firms reduce their employment levels, as described before. The overall effect is stronger in capital intensive industries, whose investments are more irreversible, as displayed in Figure 17.

Excess of capacity	(1)	(2)	(3)	(4)
EP_temporary	-3.520***	-1.947**	-2.249**	-1.785*
	(1.156)	(0.954)	(0.896)	(0.966)
1990 K/L	0.000	0.000		
	(.)	(.)		
Interaction 1	2.153**	2.435*		
	(1.042)	(1.248)		
Average K/L			0.000	0.000
			(.)	(.)
Interaction 2			1.458	2.223
			(1.486)	(1.665)
Value added		0.000		0.000
		(0.000)		(0.000)
Change # plants		-0.003		-0.007
		(0.004)		(0.006)
Country FE	Yes	Yes	Yes	Yes
Sector FE	Yes	Yes	Yes	Yes
Country-sector FE	Yes	Yes	Yes	Yes
Year-sector FE	Yes	Yes	Yes	Yes
Year-country FE	Yes	Yes	Yes	Yes
R^2	0.342	0.368	0.297	0.325
N	4622	3686	5560	4352

1990 and average capital intensities are constant over time and have been omitted

* significant at 10%; ** significant at 5%; *** significant at 1%

Standard errors clustered at the country-sector level.

Table 9: Protection of temporary workers

The interaction term, and thus the marginal effect of EPL Temporary, is displayed in Figure 17, and it is clear, once again, that the effect is stronger as investments become more irreversible.

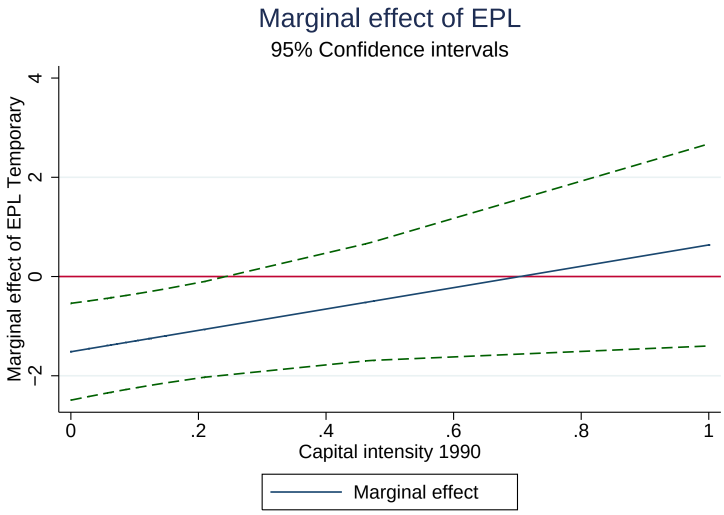

Figure 17: Marginal effect of EPL Temporary
on 1990 US Capital Intensity

4.5 ROBUSTNESS ANALYSIS

In this section, we carefully look at the consequences of increasing EPL. In Section 4.5.1 we preserve the fixed-effect dimension and look at what happens, in the short-run, when EPL increases. In Section 4.5.2, we perform a diff-in-diff analysis to assess the long-run consequences, in terms of excess capacity, of an increase in EPL.[41]

4.5.1 *Increases in EPL*

The measure of EPL used in the main analysis is available at the country level and is relatively stable over time. Hence, to capture its effect on the accumulation of excess capacity, we construct a new variable that proxies labour policy changes. We thus create a dummy variable that is equal to 1 whenever there is an increase in labour protection,[42] and interact it with the US and EU capital intensity. Results are reported in Tables 10 and 11 respectively. We observe an increase in excess capacity following an increase in the protection of workers, as firms perceive this increased protection as an additional cost. Interaction terms, although not significant, are positive, in line with the main analysis: the effect of an increase in EPL is stronger, in terms of accumulating excess capacity, in more capital intensive industries.

41 To keep this robustness analysis as general as possible, we only consider the effect of total EPL.
42 20% of the sample experiences an increase in total protection.

Excess capacity	(1)	(2)	(3)	(4)	(5)	(6)
Shock EPLT	6.748**			5.621*		
	(3.374)			(3.136)		
Shock EPLR		7.018**			5.303*	
		(3.440)			(3.119)	
Shock EPLTP			6.743**			5.695*
			(3.413)			(3.157)
Interaction 1	1.459	0.422	1.493			
	(2.635)	(3.320)	(3.115)			
Interaction 2				3.416	3.035	2.976
				(3.456)	(4.400)	(4.149)
Value added	0.000	0.000	0.000	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Change # plants	0.001	0.001	0.001	0.001	0.001	0.001
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Country FE	Yes	Yes	Yes	Yes	Yes	Yes
Sector FE	Yes	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes	Yes
Year-Sector FE	Yes	Yes	Yes	Yes	Yes	Yes
Year-Country FE	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.370	0.370	0.370	0.328	0.327	0.327
N	4094	4094	4094	4795	4795	4795

1990 and average capital intensities are constant over time and have been omitted

* significant at 10%; ** significant at 5%; *** significant at 1%

Robust standard errors are reported in parenthesis.

Table 10: Increases in EPL and Capital intensity (US)

Excess capacity	(1)	(2)	(3)	(4)	(5)	(6)
Shock EPLT	17.827***			6.031*		
	(1.553)			(3.153)		
Shock EPLR		18.002***			4.967	
		(1.500)			(3.194)	
Shock EPLTP			17.464***			6.134*
			(1.722)			(3.191)
Int. 1	3.357	-0.341	11.035			
	(5.910)	(5.545)	(10.741)			
Int. 2				0.992	5.247	0.352
				(5.837)	(7.535)	(6.531)
Value added	0.000	0.000	0.000	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Change # plants	-0.000	-0.000	-0.000	0.001	0.001	0.001
	(0.010)	(0.010)	(0.010)	(0.001)	(0.001)	(0.001)
Country FE	Yes	Yes	Yes	Yes	Yes	Yes
Sector FE	Yes	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes	Yes
Year-Sector FE	Yes	Yes	Yes	Yes	Yes	Yes
Year-Country FE	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.494	0.494	0.494	0.327	0.327	0.327
N	1868	1868	1868	4793	4793	4793

1990 and average capital intensities are constant over time and have been omitted

* significant at 10%; ** significant at 5%; *** significant at 1%

Robust standard errors are reported in parenthesis.

Table 11: Increases in EPL and Capital intensity (EU)

4.5.2 *Diff-in-diff*

In this section, we apply the diff-in-diff analysis to evaluate the long-run effect of increases in labour protection legislation.[43] We perform two different types of analysis, to evaluate respectively a 2-year and multi-year effect. In the 2-year effect, we simply compare the treated and control group at the end and beginning of our sample. Still, countries can change labour policy at different years, so we also perform a multi-year effect to take this into account. To this purpose, we estimate the following equations:

$$Excess\_capacity = \beta_0 + \beta_1 t + \beta_2 treated + \beta_3 (t * treated) + \tag{36}$$

$$\beta_4 K/L + \beta_5 Value\_added + u$$

$$Excess\_capacity = \beta_0 + \beta_1 dummy\_year + \beta_2 treated2 +$$

$$\beta_3 (t * treated2) + \beta_4 K/L +$$

$$\beta_5 Value\_added + u$$

where $t = 1$ in 2008 and $t = 0$ in 1990; $treated = 1$ if $EPL_{2008} > EPL_{1990}$, and 0 otherwise, $dummy\_year$ is the multi-year dummy, and $treated2 = 1$ if the annual growth rate of EPL is positive. Results are reported in Table 12.

The coefficients of the two interaction terms confirm, and to some extent, extend our predictions to the long-run, the results of the main empirical analysis: overtime, increases in labour market rigidity are detrimental to excess capacity, and countries providing more labour protection tend to experience higher excess capacity.

4.6 CONCLUSIONS AND DISCUSSION

This paper is the first effort to investigate the empirical consequences of labour rigidity on excess capacity. Labour protection impedes in fact the efficient allocation of resources towards their most efficient use, and firms, that perceive EPL also as an additional cost, reduce their labour force and sub-optimally exploit their existing capacity. Whereas in Chapter 3 we look at the ex-ante consequences of EPL on the investment decision, in this Chapter we look at the ex-post consequences. In other words, we look at the short run output adjustments and at CU rates as a function of EPL and capital intensity. Our results show

43 We also performed an aggregate data analysis on the observations experiencing negative output gaps, but the effect were not particularly significant.

	(1)	(2)
t	1.620	
	(1.405)	
treated	0.000	
	(.)	
t*treated	**3.278**	
	(2.984)	
K/L	-0.000	-0.000
	(0.000)	(0.000)
Value Added	0.000	-0.000
	(0.000)	(0.000)
Dummy_treatment_multi		0.000
		(.)
t*Dummy_treatment_multi		**4.077****
		(1.848)
Year FE	No	Yes
Country FE	Yes	Yes
Sector FE	Yes	Yes
R^2	0.077	0.121
N	399	372

* significant at 10%; ** significant at 5%; *** significant at 1%

Standard errors are reported in parentheses.

Table 12: Diff-in-diff on micro excess of capacity

that a tightening in dismissal restrictions may have ambiguous effect on excess capacity, depending on the type of protection considered and on the underlying complementarity between the factors of production: skilled and capacity vs. and unskilled and capacity. Still, we confirm the predictions of Chapter 3 and observe that an increase in dismissal restrictions for regular workers generates excess capacity.

Furthermore, we also look at the role of investment irreversibility in the generation of excess capacity, and find a very robust evidence: an increase in labour protection is more detrimental, in terms of excess capacity, in capital intensive industries.

To assess the robustness of these results, we implement two different analysis: first of all, we preserve the fixed-effect dimension and evaluate the impact of increases in EPL on the short-run excess of capacity. We also perform a diff-in-diff analysis to measure the difference in excess capacity of those observations experiencing an increase in EPL, relatively to those that did not. Both these alternative specifications predict a positive effect of EPL on the accumulation of excess capacity.

This paper contributes to the animated debate regarding the importance of reducing labour market rigidity. Former analysis have stressed the impact of EPL on a variety of parameters, ranging from labour productivity to job turnovers. This work sheds some light on the short-run consequences of myopic labour regulations, and it proves, jointly with the underlying theoretical analysis, how excessive labour protection may alter firms' rational investment decisions by making them choose unsustainable commitment levels. The findings of this work may also be important as they succeed in taking account certain sector characteristics, such as capital intensity. Hence, policy makers may benefit from these evidences by implementing sector-specific labour regulation.

A

APPENDIX

A.1 THE THEORETICAL PAPER

A.1.1 *Stylized facts: probit analysis*

To investigate the effect of labour costs on the rise of excess capacity, we also estimate the impact of labour costs on the probability of incurring negative output gaps, that is, the probability of generating excess capacity. Table 13 reports the estimation result for this probit analysis, column (1), and the marginal effect, column (2). The marginal effect of unit labour costs is positive and significant, suggesting that an increase in labour costs increases the probability of incurring a negative output gap by 0.55. The effect of an increase in GDP per capita is instead negative, although not significant.

Probability of having a negative output gap	Estimation	Mfx
Unit labour cost	1.409***	0.550***
	(3.91)	(4.06)
Log GDP per capita	-0.283	-0.111
	(-1.91)	(-1.93)
Cons	1.575	
	(1.21)	
N	638	638

t statistics in parentheses

* significant at 10%; ** significant at 5%; *** significant at 1%

Standard errors clustered at the country-sector level.

Table 13: Probability of having a negative output gap

A.2 THE EMPIRICAL PAPER

A.2.1 *Countries and sector*

Our sample includes the following European countries: Austria, Belgium, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Luxembourg, Netherlands, Poland, Portugal, Slovakia, Slovenia, Spain, Sweden and the United Kingdom. We include the following Naics 1.1 industries:

- 15: Food products and beverages;
- 17: Textiles;
- 18: Wearing apparel; dressing and dyeing of fur
- 19: Tanning and dressing of leather; luggage, handbags, saddlery, harness and footwear
- 20: Wood and of products of wood and cork, except furniture; articles of straw and plaiting materials
- 21: Pulp, paper and paper products
- 22: Publishing, printing and reproduction of recorded media
- 23: Coke, refined petroleum products and nuclear fuel
- 24: Chemicals and chemical products
- 25: Rubber and plastic products
- 26: Other non-metallic mineral products
- 27: Basic metals
- 28: Fabricated metal products, except machinery and equipment
- 29: Machinery and equipment n.e.c.
- 30: Office machinery and computers
- 31: Electrical machinery and apparatus n.e.c.
- 32: Radio, television and communication equipment and apparatus
- 33: Medical, precision and optical instruments, watches and clocks
- 34: Motor vehicles, trailers and semi-trailers
- 35: Other transport equipment
- 36: Furniture; manufacturing n.e.c.

A.2.2 *Capacity utilization methodology*

This section quickly reports the collection and aggregation methodology for gathering the CU rate f the Business and Consumer Survey.[1] For each country included in the sample, Table 14 reports the sampling method, the sample size coverage, the response rate, and the weighting scheme.

1 More detailed information can be found at http://ec.europa.eu/economy_finance/db_indicators/surveys/documents/bcs_user_guide_en.pdf and at http://ec.europa.eu/economy_finance/db_indicators/surveys/documents/metadata2/metadata_all_indu_en.pdf.

Country	Sampling method	Size	Coverage	Response rate	Weights
Austria	Self-selection	1680	33% of total employment	45%	Employment; Value added
Belgium	Random selection for SMEs (activity, turnover), exhaustive inclusion for large firms	1270	46% of manufacturing turnover	95%	Turnover
Czech Republic	Stratified panel (turnover, branches)	1000	55% sector employment 65% turnover	85%	Turnover; Employment
Denmark	Stratified random sampling (34 strata by activity); firms > 20 employees	500	9% firms, 60% total employment	85%	Employment
Estonia	Panel	275	73% Employment	80%	Employment
Finland	Random sampling for SMEs, all large companies	700	50% total employment and 50% manufacturing turnover	80%	Turnover; Employment

France	Stratified sample (employment, activity): number of firms in one strata is proportional to strata turnover. Within strata, random sampling. All large firms (>500 employees, or >150 mn turnover)	4000	71% turnover	80%	Turnover, Employment
Germany	Panel	3800	25% total employment, 40% manufacturing turnover	80%	Employment; Value added
Greece	Cluster sampling (employment, activity)	1065	32%	70%	Turnover
Hungary	Random sampling (stratified by employment), annual sample update	1500	15% employment	27%	No weighting
Ireland					
Italy	Panel based on stratified random sampling (firms with $\geq$ 10 employees)	4100	6% of firms in the population	97%	Employment
Luxembourg	Choice of most important firms by branch	120	80%	98%	Value added

Netherlands	Stratified sampling (probability proportional to size)	1368	33% employment	80%	Employment; Activity
Poland	Stratified sampling with simple random sampling	3500	58% sector employment of firms with > 10 employees	96%	Sold production
Portugal	All firms with > 200 employees are included. Firms with < 200 are stratified by size	1242	37% manufacturing employment	80%	Turnover
Slovakia	Stratified sampling with simple random sampling	756	61% sector employment, 72% turnover	79%	Employment, turnover
Slovenia	Stratified sampling with simple random sampling (by employment and activity); all large enterprises	744	77% of Medium firms (79% medium firm employment) and 27% of small firms (30% small firms employment); 83% manufacturing employment; 48% total number of firms	92%	Employment, relative importance of firm in the panel
Spain	Stratified random sampling	2268	23% manufacturing employment	60%	Employment; Gross value added
Sweden	Cut off (only firms with > 100 employees)	1594	62% manufacturing employment	75%	Value added; Employment

United Kingdom	Regular panel of participants	1500	50% of CBI sample	500 responses	Output, gross value added

Table 14: Capacity utilization rate: collection technique

A.2.3 *Demand uncertainty*

As an extension to the main analysis, we evaluate the joint impact of EPL and demand volatility to assess which industries suffer more from an increase in labour protection. In this way, we extend the predictions of Cunat and Melitz (2012) to our setting. In their framework, labour flexibility may act as a comparative advantage since firms can move resources, and workers, to their most efficient use when it is more relevant to do so. In other words, countries with a relatively flexible market have a comparative advantage in exporting in relatively more volatile industries. In our setting, we expect to observe excess capacity in sectors more subjected to demand variations, and we also expect that an increase in labour protection is more detrimental to firms operating in more volatile industries. To measure demand volatility, we calculate the Standard Deviation of the annual-country-sector output growth. Table 15 reports the results for the different classifications of labour protection. Of all the classifications considered, only the protection of temporary workers in Specification (3) significantly interacts with demand volatility. The effect of EPL alone is positive, and, more interestingly, an increase in the protection of temporary workers is more binding in industries with a high demand volatility. These industries need flexible labour to react to demand changes, as stressed by Cunat and Melitz (2012). Thus, an increase in firing restrictions is inevitably more binding in those industries that need flexible labour to accommodate demand fluctuations. In equation (37) and Table 15 we look at the joint impact of EPL and demand volatility:

$$\begin{aligned} EC_{jct} = \beta_1 + \beta_2 EPL^i_{ct} + \beta_3 Volatility_{jct} + \beta_4 EPL^i_{ct} * Volatility_{jct} + \\ + \beta_4 (X_{jct}) + \mu_j + \mu_c + \mu_{jt} + \mu_{ct} + \varepsilon_{jct} \end{aligned} \tag{37}$$

As a last step, we look at the relation between capital intensity and demand volatility and wonder if capital intensity may somehow soften the impact of demand shocks. Results are reported in Table 16 and suggest in fact that an increase in the level of capital intensity may reduce the impact of demand volatility on the accumulation of excess capacity.

Excess capacity	(1)	(2)	(3)
EP_collective	7.118**		
	(3.351)		
Demand volatility	0.000	0.000	0.000
	(.)	(.)	(.)
Interaction term	0.076		
	(0.259)		
EP_regular		3.250	
		(2.251)	
Interaction term		-0.050	
		(0.475)	
EP_temporary			1.223*
			(0.681)
Interaction term			0.547*
			(0.291)
Country FE	Yes	Yes	Yes
Sector FE	Yes	Yes	Yes
Year and country FE	Yes	Yes	Yes
Year and sector FE	Yes	Yes	Yes
R^2	0.267	0.297	0.298
N	3812	5523	5523

* significant at 10%; ** significant at 5%; *** significant at 1%

Standard errors clustered at the country-sector level.

Table 15: Demand uncertainty

Excess capacity	(1)	(2)
K/L	-11.313*	-6.907
	(5.891)	(4.314)
Demand volatility	0.000	0.000
	(.)	(.)
Interaction term	-0.658	-3.069**
	(1.350)	(1.375)
Country FE	Yes	Yes
Sector FE	Yes	Yes
Year and country FE	No	Yes
Year and sector FE	No	Yes
R^2	0.003	0.310
N	4947	4947

* significant at 10%; ** significant at 5%; *** significant at 1%

Standard errors clustered at the country-sector level.

Table 16: Capital intensity and demand uncertainty

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