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Productivity or Employment: Is It a Choice?

Andrea De Michelis, Marcello Estevão, and Beth Anne Wilson

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Prepared by Andrea De Michelis, Marcello Estevão, and Beth Anne Wilson[1]

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Abstract

Traditionally, shocks to total factor productivity (TFP) are considered exogenous and the employment response depends on their effect on aggregate demand. We raise the possibility that in response to labor supply shocks firms adjust efficiency, rendering TFP endogenous to firms' production decisions. We present robust cross-country evidence of a strong negative correlation between growth in TFP and labor inputs over the medium to long run. In addition, when using instruments to capture changes in hours worked that are independent of TFP shocks, we find that cross-country increases in labor input cause reductions in TFP growth. These results have important policy implications, including that low productivity growth in some countries may partly be a side effect of strong labor market performance. By the same token, countries facing a declining workforce, say, because of aging, may see accelerating TFP as firms find better ways of employing workers.

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Email Addresses: mestevao@imf.org, andrea.demichelis@frb.gov, bethanne.wilson@frb.gov

[1] De Michelis and Wilson work at the Federal Reserve Board. Estevão works at the IMF. We thank Rebecca Spavins and Daniel Van Deusen for excellent research assistance, and benefited from comments of Barbara Fraumeni, Andrea Raffo, Andrew Sharpe, seminar participants at the 2013 AEA meetings, and an anonymous referee. The views in this paper are solely the responsibility of the authors and should not be interpreted as reflecting the views of the Federal Reserve System, the International Monetary Fund, or any other person associated with either institution.

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I. INTRODUCTION

Over the past decade, policymakers in Canada have expressed concern about the country's slow rate of productivity growth. Indeed, total factor productivity (TFP) growth in Canada has consistently underperformed that of the other G-7 economies. Output growth, however, has been relatively stronger, reflecting a higher-than-average pace of employment growth over the last 40 years. Given the strong performance of output, how worried should policymakers be about the weaker TFP growth? In traditional economic theory, changes in TFP are a key driver of economic growth and, to a great extent, are considered exogenous. However, the experience of Canada leads to questions about the traditional view. More specifically, could TFP respond endogenously to the availability of labor? Instead of taking TFP as given, can firms and industries vary TFP and employment depending on factor endowment and labor costs – essentially "choosing" an optimal tradeoff between TFP and labor intensity on the production frontier?

In this paper, we examine the exogeneity of TFP to changes in labor use in the production process. We begin by establishing a negative historical relationship between TFP and labor input across industrial countries. In particular, we find a negative correlation between TFP growth and hours growth from 1970 to 2007 across the main OECD economies. Countries that have stronger growth rates of TFP tend to have lower hours growth. This result is robust across databases, holds up over smaller time periods, is not driven by the business cycle, and does not reflect differences in industry composition across countries. Related research documents a similar relationship between labor productivity and labor input, although in this case the negative correlation is expected to be temporary and part of the hiring and firing process (Estevão, 2007, and Dew-Becker and Gordon, 2012). Nonetheless, we document that all the basic results showing a negative relationship between TFP growth and hours growth in the medium-to-long run remain if labor productivity growth is used to measure changes in production efficiency.

We then turn to the question of causality. While it is difficult to believe that countries such as Canada, the United States, and Germany have significantly different technological capacity or knowledge, they do have different labor endowments, immigration policies, regulations, and tax policies. We exploit these differences to assess the response of TFP growth to exogenous movements in labor supply. In particular, we instrument for the growth in hours using taxes and population growth, both of which should be independent of TFP. Using these instruments, we find a continued significant negative correlation between TFP growth and growth in total hours; a result that is robust to many variations, including using labor productivity growth as a proxy for changes in production efficiency and dropping particular countries from the sample.[1]

[1] Measurement issues could also be behind some of the differences in TFP growth across countries in our sample. For instance, Diewert and Yu (2012) argue that TFP growth could have averaged 1 percent from 1961 to 2011 in Canada, as opposed to the 0.3 percent calculated by Canada's statistical institute. The authors arrived to this conclusion by estimating a much slower growth in capital services for a given GDP growth path than implied by the

These results raise interesting and important policy questions. For instance, should countries with strong employment growth, such as Canada, worry less about their relatively weaker TFP? To what extent can policy influence the tradeoff between TFP and labor usage? And are there social welfare implications for such a choice? In response to aging populations, will countries experience rising TFP as firms find ways to utilize existing workers more effectively? The case of Japan, with its low employment growth and relatively weak TFP growth, suggests other factors may be at play. Therefore, can policies such as increasing labor and product market flexibility influence the ease with which industries can move from one TFP/labor mix to another in response to shocks?

Following this introduction, section II of the paper describes the datasets used. Section III presents our results while section IV discusses additional robustness checks. Section V concludes with a discussion of the implications of our results for policy and future research.

II. Data sources

To examine the relationship between productivity and labor input, we use several databases that allow for cross-country comparisons over long time periods. The main data sources are the Total Economy Database (TED) from the Conference Board and World KLEMS (table 1). Both databases provide cross-country measures of output and input (such as GDP, employment, and hours) as well as derived variables (such as TFP) using standard growth accounting methodology. TED is constructed to enhance international comparability and spans over 123 countries from 1950 to 2011. While TED contains information only for the aggregate economy, World KLEMS also includes a breakdown at the industry level. However, World KLEMS generally covers only the 1980-2009 period and data for some countries of interest are missing or incomplete; moreover, the dataset is still a work in progress and thus international comparability is more problematic. To address some of these limitations, we integrate World KLEMS with data from the original European Union (EU) KLEMS initiative, which focused on European countries and for which data are available only up to 2007.2 We also use the EU AMECO dataset to check for the robustness of some results.

In our baseline analysis, we examine 20 OECD-member countries from 1970 to 2007.[3] Though data for a few additional countries are available, we restrict our analysis to a set of countries

official series. This adjustment puts Canada nearer to the middle of the TFP range for our sample and time period, but it does not invalidate the main finding of this paper. More generally, the negative relationship between TFP growth and hours growth does not appear to depend on the experience of a particular country or particular measurement errors.

[2] TED, World KLEMS, and EU KLEMS are all publically available at http://www.conference-board.org/data/economydatabase, http://www.worldklems.net, and www.euklems.net, respectively. For a review of how these datasets have been assembled and used, see van Ark et al. (2011), Jorgenson (2012), Jorgenson et al. (2010), O'Mahony and Timmer (2009), and Timmer et al. (2010).

[3] Country coverage for Austria, Canada, France, Germany, Italy, Spain, the United Kingdom, and the United States is available in World KLEMS. EU KLEMS is used to supplement this list, adding Australia, Belgium, Denmark,

which we consider to be relatively close to their respective technical frontiers and thus for which it is reasonable to discuss a tradeoff between employment and technology growth. For instance, South Korea has posted a large increase in TFP and in working hours in the last 40 years, but that was the result of a rapid catch-up to the technological frontier. We also do not consider the Great Recession and subsequent recovery in our baseline case, in part because data would not be available for some countries but also because our study focuses on a long-run relationship. That said, although the dynamics of TFP, employment, and hours have been different than typically seen during recessions—particularly because of the depth of the recession and evidence of greater-than-usual labor hoarding by firms in some countries, as documented in van Ark et al. (2011)—our main results hold if we extend our analysis beyond the Great Recession.

We also used data on population and taxes (table 2). Population estimates come from TED and the United Nations (UN) Department of Economic and Social Affairs. Tax data come from the 2010 update of McDaniel (2007).

III. TFP GROWTH IS NEGATIVELY RELATED TO LABOR INPUT GROWTH

A. Basic results and some robustness tests

Using the data described above, we begin by calculating the simple long-run relationship between TFP and labor input for the countries in our sample. Chart 1 shows a scatterplot of the annualized percent change in TFP on the percent change in total hours for 20 OECD countries from 1970 to 2007 using TED. The fitted line through the country averages shows a negative relationship, with a 1 percentage-point increase in the growth rate of hours related to a 0.5 percentage-point decline in TFP growth. The relationship holds when just the G-7 countries are included, shown in red, suggesting that the most advanced economies—the countries closest to the technological frontier—have variation in TFP growth that is negatively related to labor input.

This negative relationship is robust to a broad range of factors. First, although we have chosen to use the most comprehensive measure of labor input (total hours) in our calculations, there is also a negative correlation between TFP growth and employment growth of roughly the same magnitude (chart 2). TFP growth is also negatively correlated with the rate of change of hours per capita (not shown), but we expressly chose to not conduct our analysis in per capita terms because, as we will argue later, population growth may be one of the factors driving the tradeoff between productivity and labor input.

Second, measurement issues are always a concern when calculating an unobservable or residual such as TFP. Indeed, TFP measures tend to be procyclical, as labor hoarding at the beginning of recessions depresses observed TFP, while a more intensive use of incumbent workers during the

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Finland, Japan, and the Netherlands to the dataset. Data for these 14 countries and an additional six (Greece, New Zealand, Norway, Portugal, Sweden, and Switzerland) from 1970-2011 are included in TED, though only at the total economy level.

initial phase of expansions boosts observed TFP (Comin, 2008, and Basu, 1996). Cyclical changes in the quality of the employed pool also affect measured TFP. However, these cyclical effects should not be at play in correlations between averages over 40 years. Also, the results survive robustness tests, including the exclusion of countries and the utilization of different databases. Table 3 underlines these points by showing estimates for the basic regression of hours (or employment) growth on TFP growth using TED and KLEMS. Across databases, the long-term negative correlation remains robust and quite similar.

Third, although we are focusing on average relationships across the last 40 years rather than cyclical patterns, the negative correlation between TFP growth and hours growth holds up across shorter time periods. Table 4 presents estimates of the correlation using the TED database for the entire period and for each decade individually. Generally, the coefficients are significant, negative, and remarkably similar across decades, although the relationship is less negative and notably weaker in the 1990s. This exception could be the result of a widespread slowdown in European TFP and a pick-up in U.S TFP growth in the 1990s.

Fourth, we also examine whether the negative relation between TFP growth and hours growth is driven by fluctuations around business cycle peaks. To this end, we repeat the exercises described above excluding the years an economy was in recession for at least a month, a procedure which reduces the sample period by about 25 percent.[4] The results in tables 5 and 6 show that the relation holds also for the restricted sample. Indeed, the estimated coefficient is not greatly different than for the full sample, and the fit is somewhat better. In sum, our basic result does not seem to be driven by fluctuations at the business cycle frequency, supporting our intuition that the negative trade-off between TFP and hours is driven by medium- to long-run factors.

B. Industry-level evidence

There is considerable variation in the relationship between TFP and hours growth by industry. Combining the EU and World KLEMS databases, we are able to construct correlations of TFP growth and hours growth across decades by industry for 14 countries.[5] The data are classified into 10 major industry groups: agriculture, mining, manufacturing, electricity, construction, wholesale and retail trade, transportation, hotels and restaurants, finance, and other services (including education and health). Table 7a presents the industry results together with those for the total economy. The industries are arranged from most negative to least negative correlation between TFP and hours growth. The hotels and restaurants sector appears to have the largest and

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[4] In the tables presented here, we removed all years which contained at least 1 month of recession. An alternative exercise that excludes only those years with at least 6 months of recession finds similar results and removes 17 percent of the sample.

[5] The 14 countries are Austria, Canada, France, Germany, Italy, Spain, the United Kingdom, and the United States from the World KLEMS database and Australia, Belgium, Denmark, Finland, Netherlands, and Japan from the EU KLEMS database.

most significant negative correlation followed by manufacturing and other services. At the other end of the range, TFP and hours in the transportation, mining, and construction industries are negatively correlated, but the coefficients are much smaller and not different from zero statistically. These results vary somewhat by country group and labor input, as can be seen, for example, in table 7b which presents results for the G-7 countries alone. However, the basic result remains the same: The cross-country relationship between TFP and labor input is not constant across sectors but is almost always negative.

The variance across sectors suggests that one possible reason for the long-term divergences across countries in the trade-off between TFP and hours growth could be differences in countries' industry composition. To check for this effect, we hold industry composition constant by constructing aggregate measures of TFP and hours growth for each country weighting both hours and TFP by the industry value-added shares for the United States. The results in table 8 show that holding sectoral composition fixed across countries does not change the size and increases the statistical significance of the correlation. This result implies that within-industry differences across countries (rather than differences in industry composition) are driving the dispersion in the relationship between TFP growth and hours growth, at least at the level of disaggregation considered in our analysis.[6]

C. Stability of country positions

We can divide the set of countries into groups based on where they fall relative to the sample averages of TFP growth and hours growth (chart 3a). Specifically, a number of European countries, importantly Germany and France, have above average TFP growth during the whole sample period but below average hours growth. In contrast, countries, primarily outside Europe, such as Canada and the United States have below average TFP growth on average in the past 40 years but stronger-than-average hours growth over the full sample. In the other quadrants, Japan stands out as having both low TFP and hours growth.

These groupings are fairly robust across decades (chart 3b). For the most part, countries do not switch their quadrants dramatically over the almost four decades of our sample. However, there is a notable shift of European countries, even Germany, toward greater employment growth and weaker TFP growth over time. Increased labor utilization and reduced labor productivity growth in Europe have been well documented and have been partly attributed to policies to liberalize labor markets, which reduced labor costs to the firm and lowered disincentives to work resulting in an overall positive labor supply shock.[7]

[6] We have also conducted a similar exercise using more disaggregated sectors (with 28 sectors rather than 10) for a smaller set of countries, using the EU KLEMS database only. We find that the negative relation between TFP growth and labor input growth holds and the size of the coefficient does not significantly change.
[7] See Jackman et al.(2005).

IV. EXOGENOUS CHANGES IN LABOR INPUT SEEM TO CAUSE OPPOSITE CHANGES IN TFP

The results above suggest a robust negative relationship between TFP growth and labor input growth, but they do not provide any indication of causality. Does the negative correlation reflect the fact that exogenous changes in TFP fail to increase aggregate demand and thus result in a decline in hours, as there is less need for labor? Or, do positive changes in hours—possibly through reductions in labor cost or the available supply of labor—lead firms to deemphasize efficiency? To address these questions, we start by trying to identify shocks to hours growth that are independent of TFP growth and use those to instrument for labor input in our baseline regressions.

First, we consider the role of taxes. There is evidence that taxes play an important role in determining the utilization of labor (e.g. Prescott, 2004). By driving a wedge between the marginal product of the worker and the marginal cost of the firm as well as between the marginal effort of the worker and the marginal benefit the worker receives, taxes can reduce both the demand and the supply of labor. Ohanian et al.(2008) find that differences in the tax wedge—a broad measure encompassing taxes on income, payroll and consumption—account for much of the variance in hours worked across countries and over time.[8] However, in principle, labor taxes should not directly affect the growth of TFP. With this in mind, we calculate the average tax wedge for each country and use it as an instrument for hours growth. As defined, an increase in our measure of the tax wedge reflects a reduction in the underlying income, payroll, or consumption taxes. As such, an increase in the tax wedge should cause labor input to rise as firm costs or worker disincentives are reduced. Step 1 regression in table 9 shows that the tax wedge is a good predictor of hours worked, with a highly significant coefficient.[9] In addition, the sign comes in as expected; lowering taxes, increases the wedge, and increases the growth rate of hours. Moreover, as shown in step 2, our measure of predicted hours using the tax wedge as instrument is significantly negatively correlated with TFP growth. The final table shows that the tax wedge does not have an independent effect on TFP growth for the 1970s, 1980s, and the 2000-2007 period. However, the tax wedge has a small independent effect—significant only at the 10 percent level—for the full sample period of 1970-2007, which might invalidate it as an instrument for hours of work in the baseline regression. It is not clear why labor taxes should

[8] More formally, the tax wedge $1-\tau_t$ is defined as:

$$1-\tau_t = \frac{1-\tau_{ht}}{1+\tau_{ct}},$$

where τ_{ht} stands for labor income (including payroll) tax and τ_{ct} for consumption tax. Ohanian et al.(2008) show that in a standard one-sector real business cycle growth model $1-\tau_t$ is equal to the ratio of the marginal rate of substitution between consumption and leisure to the marginal product of labor. Thus, the wedge measures the percentage deviation between the marginal rate of substitution and the marginal product of labor.

[9] Data on the tax wedge for 1970-2007 are available for only 15 of the 20 OECD countries earlier considered.

affect the growth rate of TFP; it may be that our tax wedge variable marginally captures taxes that affect the firm's choice of capital or labor efficiency independent of the cost of labor.

To provide additional support to these results, we use population growth as an alternative instrument. Demographics have long been understood to be an important driver of labor supply; as such, firms located in countries with faster population growth may choose to hire more working hours independently of the technology available to them. However, in principle, population growth should not be linked to changes in total factor productivity. The step 1 results in table 10 indicate that population growth is a good predictor of hours growth. In step 2, we generally find a negative coefficient on hours growth, although it is a bit smaller (in absolute value) than in the baseline OLS regression (table 3) using the TED data. In addition, as seen in the third set of results in table 10, population growth is not statistically significant once it is paired with hours growth as an explanatory variable of TFP growth, indicating that population affects TFP only through hours worked and, thus, appears to be a good instrument for TFP.[10]

All told, we find evidence pointing to causality going from hours growth to TFP growth. In particular, it appears that faster population growth leads firms to choose to employ more work hours while stressing efficiency less. The evidence from using tax wedge as instrumental variable is a bit more mixed but still supportive. We believe these results call for future research to further confirm the direction of causality between these key macroeconomic variables and the reasons behind it.

V. Results are Robust to Using Labor Productivity as a Proxy for Efficiency Changes

Throughout the paper we have focused on TFP growth as the best empirical representation of what macroeconomic theory considers "production efficiency." However, TFP is a derived measure and, even though we believe measurement errors are not driving our results, alternative efficiency measures could generate different results. An easy robustness check is to proxy for changes in production efficiency by using labor productivity growth; measured as percent changes in GDP divided by hours of work.

Labor productivity should be trivially negatively correlated to changes in work hours in the short run but there is no reason to assume that this correlation would be maintained in the medium to long run. For instance, as hiring increases following a reduction in unions' wage demands, labor productivity growth would decline. As firms adjust investment to return capital labor ratios to steady-state values, this initial slowdown in labor productivity would be reversed.[11] In this example, the initial wage shock would raise hours growth during the transition phase but keep medium-term labor productivity growth unchanged. In contrast, a negative relationship between

[10] We also duplicated this result using working age population, rather than total population.
[11] Blanchard (1997) and Estevão (2007).

the growth in hours and labor productivity growth could remain in the medium term, if, as we argue here, there is a trade-off between investing in efficiency gains (i.e. making TFP grow faster) and using the newly available labor.

Indeed, chart 4a shows that labor productivity growth is negatively correlated to changes in hours of work in the long run. Moreover, the country ordering in chart 4a is similar to the ordering in chart 1, indicating a close mapping from the relationship between TFP growth and hours growth shown earlier. Chart 4b illustrates the same pattern of migration to the lower right quadrant of high hours growth-low productivity growth in the latter part of the sample period as observed in chart 3b. Our basic instrumental variable regressions for labor productivity growth produce comparable results to the estimations using TFP growth as dependent variable, reaffirming that exogenous changes in hours of work are negatively related to improvements in production efficiency. Using tax wedges (Table 11) or population growth (Table 12) as instrumental variables, growth in hours of work affects labor productivity growth negatively for the whole sample period, 1970-2007. The negative relationship is maintained within each of the four decades, although often the hours growth coefficient is estimated imprecisely.

The sectoral regressions are also similar (tables 13a and b), although the coefficients of hours growth tend to be larger and more significant, and the ordering of the sectors changes. As it was the case when using TFP to measure production efficiency, controlling for sectoral composition across countries does not affect the aggregate negative relationship between hours growth and labor productivity growth.[12]

VI. Conclusions

As economists, we are used to thinking about total factor productivity—a catch-all term for technological advances and improvements in firms' management and organization—as an exogenous determinant of economic growth. Canonical research by Robert Solow over 50 years ago linked TFP to long-run per capita GDP growth and to differences in growth rates across countries (Solow, 1956). Since then, much research has focused on identifying factors that affect TFP such as funding for research and development, barriers to entrepreneurship, and the degree of market regulation.[13] The labor market impact of TFP growth has been less certain. Traditionally, the response of labor input to changes in TFP depends on a variety of factors, including whether the change is labor saving or labor augmenting and whether the shock in TFP raises aggregate demand (Blanchard et al., 1995). Real business cycle literature has argued that TFP is positively correlated with hours worked, possibly because of labor hoarding or variation in the rate of capacity utilization (Burnside et al., 1995). Other more related work to ours often finds a short- to medium-run negative relationship between hours and labor productivity (not

[12] All sectoral results are available upon request.
[13] See for example, Romer (1990), Holmes and Schmitz (2001), and Acemoglu et al. (2007).

TFP) suggesting that sometimes aggregate demand or investment may not adjust quickly enough to bring labor productivity growth back to previous rates.[14]

The results in this paper tell a somewhat different story. The long-run negative correlation we find between TFP growth and hours growth raises questions about how conclusive Solow's earlier result is in explaining cross-country differences in output performance over the long run. The relatively strong growth performance of Canada in the face of weak TFP growth is a case in point. More generally, the finding that cross-country variance in technology (a key determinant of TFP growth) is significantly greater than the variance in output performance (Comin et. al, 2006) suggests that other factors besides TFP growth must be at play in determining long-run output growth.

Our results also raise questions about the factors that influence TFP growth. We are not arguing that TFP is entirely determined by labor endowment. However, our instrumental variable results point to channels through which firms, industries, and countries may vary the intensity and efficiency with which they utilize labor, depending on labor cost and labor availability. Put another way, the results suggest that studies trying to explain TFP growth by focusing on R&D investment and institutions could be missing an important variable: the availability of inputs. For instance, having abundant labor could tilt business decisions toward not paying the costs of implementing innovations or reorganizing production that would ultimately result in faster TFP growth. In fact, past work have discussed how the process of introducing new technologies could be costly and interact in nontrivial ways with demographic forces (e.g., Beaudry et al, 2005), but more research on the topic is clearly needed.

These results also suggest that for countries close to the technological frontier with good institutions and broadly adequate support for research, development, and entrepreneurship, concerns about slow TFP growth may be less pressing as long as labor growth remains strong. In addition, they also suggest that countries which enact policies to reduce the cost of labor or increase immigration should not necessarily be alarmed to find TFP growth slowing—as was the case for a number of European countries during the 1990s. However, if there is a tradeoff between TFP growth and hours growth, as countries face the aging of their population, like Japan, every effort should be made to boost immigration of well-qualified foreign workers and to create an environment where firms and industries can improve technology easily.

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[14] For instance, Estevão (2007) shows that the fast increase in employment in several euro-area countries following a period of wage moderation in the mid-1990s was the main factor behind slower labor productivity growth in the region. However, using a similar framework to the one proposed in Blanchard (1997), the same paper shows that as low wages raise profit rates to a level above the (exogenously given) user cost of capital, investment would rise, capital deepening would speed up, and labor productivity growth would return to its original steady state pace. Dew-Becker and Gordon (2012) documents that investment rates in several euro-area countries have not quite recovered from the wage moderation process, resulting (so far) in a more subdued labor productivity growth path.

Finally, if under certain circumstances there is a tradeoff between TFP growth and hours growth, such as for countries near the production frontier, then there may be social welfare implications of pursuing policies that favor TFP growth over that of hours. Policies that increase production efficiency at the expense of hours of work and/or employment may result in increased unemployment, loss of income for workers, and reduced overall well-being. Indeed, a budding literature (e.g. Layard, 2005) has stressed the large negative effects of joblessness on human happiness.

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Table 1: Data on the Sources of Economic Growth

Database		Sectoral Data	Variable Coverage	Country Coverage	Time Coverage
Total Economy Database		No	Total Employment Total Hours Worked TFP	Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Italy, Japan, Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, United Kingdom, United States	1970-2011
KLEMS	**EU**	Yes	Total Employment Total Hours Worked TFP	Australia, Belgium, Denmark, Finland, Japan, Netherlands	1980-2007
	World			Austria, Canada, France, Germany, Italy, Spain, United Kingdom, United States	
AMECO		No	Total Employment TFP	Canada, France, Germany, Italy, Japan, United Kingdom, United States	1970-2011

Table 2: Other Data Sources

Database	Sectoral Data	Variable Coverage	Country Coverage	Time Coverage
Total Economy Database	No	Population	Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Italy, Japan, Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, United Kingdom, United States	1950-2011
United Nations	No	Population	Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Italy, Japan, Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, United Kingdom, United States	1950-2020
McDaniel	No	Tax rates	Australia, Austria, Belgium, Canada, Finland, France, Germany, Italy, Japan, Netherlands, Spain, Sweden, Switzerland United Kingdom, United States	1950-2010

Table 3: Labor Input Growth vs. TFP Growth by Database

Database	TED	KLEMS†	TED	KLEMS†
Input	Employment	Employment	Hours	Hours
Constant	1.35***	0.86***	1.07***	0.74***
	(0.17)	(0.18)	(0.10)	-0.12
Coefficient	-0.53***	-0.36*	-0.49***	-0.37**
	(0.15)	(0.17)	(0.11)	(-0.09)
Observations	20	14	20	14
Adjusted R^2	0.36	0.21	0.48	0.33

†KLEMS data spans the time period 1980-2007.

Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Sources: Total Economy Database, EU KLEMS, and World KLEMS.

Table 4: Hours Growth vs. TFP Growth by Period

Period	1970-2007	1970s	1980s	1990s	2000-2007
Constant	1.07***	1.67***	1.01***	0.60***	0.91***
	(0.10)	(0.13)	(0.13)	(0.15)	(0.22)
Hours Growth	-0.49***	-0.57***	-0.41***	-0.19	-0.63***
	(0.11)	(0.13)	(0.13)	(0.18)	(0.18)
Observations	20	20	20	20	20
Adjusted R^2	0.48	0.49	0.33	0.01	0.36

Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Source: Total Economy Database.

Table 5: TFP Growth vs. Labor Input Growth Excluding Recessions[1]

Database	TED		KLEMS†	
Input	Hours	Employment	Hours	Employment
Constant	1.56***	1.87***	1.22***	1.37***
	(0.12)	(0.17)	(0.17)	(0.21)
Coefficient	-0.42***	-0.54***	-0.47***	-0.48***
	(0.10)	(0.12)	(0.12)	(0.14)
Observations	20	20	14	14
Adjusted R^2	0.48	0.52	0.51	0.46

† KLEMS data spans the time period 1980-2007.

Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Source: Total Economy Database, EU KLEMS, and World KLEMS.

[1] Sample period excludes all years with at least one month of recession.

Table 6: TFP Growth vs. Hours Growth Excluding Recessions[1]

Database	1970s	1980s	1990s	2000-2007
Constant	2.49***	1.53***	1.12***	1.53***
	(0.16)	(0.18)	(0.19)	(0.24)
Hours Growth	-0.64***	-0.35**	-0.24*	-0.91***
	(0.15)	(0.13)	(0.13)	(0.17)
Observations	20	20	20	20
Adjusted R^2	0.48	0.25	0.12	0.60

Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Source: Total Economy Database.

[1] Sample period excludes all years with at least one month of recession.

Table 7a: TFP Growth vs. Hours Growth by Sector, 1980-2007 (OECD 14)

Industry	Coefficient		Constant		Observations	Adjusted R^2
Hotels and Restaurants	-0.60**	(0.26)	0.28	(0.49)	14	0.25
Manufacturing	-0.46	(0.35)	1.19**	(0.49)	14	0.05
Total Economy	**-0.37****	**(0.14)**	**0.74*****	**(0.12)**	**14**	**0.33**
Other Services	-0.35*	(0.19)	0.11	(0.30)	14	0.15
Wholesale and Retail	-0.33	(0.48)	1.31***	(0.40)	14	-0.04
Financial Services	-0.23*	(0.12)	0.39	(0.41)	14	0.18
Electricity	-0.23	(0.26)	0.81**	(0.30)	14	-0.02
Agriculture, Forestry, and Fishing	-0.21	(0.31)	2.77***	(0.81)	14	-0.04
Construction	-0.15	(0.19)	0.24	(0.25)	14	-0.03
Mining and Quarrying	-0.13	(0.28)	0.43	(1.04)	14	-0.06
Transportation	-0.11	(0.37)	1.37***	(0.42)	14	-0.08

Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Source: World KLEMS, EU KLEMS.

Table 7b: TFP Growth vs. Hours Growth by Sector, 1980-2007 (G7)

Industry	Coefficient		Constant		Observations	Adjusted R^2
Hotels and Restaurants	-0.99**	(0.27)	1.07*	(0.50)	7	0.67
Other Services	-0.72	(0.36)	0.72	(0.50)	7	0.33
Manufacturing	-0.48***	(0.12)	1.12***	(0.19)	7	0.73
Wholesale and Retail	-0.49	(0.48)	1.74***	(0.39)	7	0.01
Total Economy	**-0.47****	**(0.15)**	**0.78*****	**(0.11)**	**7**	**0.59**
Electricity	-0.42	(0.44)	0.41	(0.47)	7	-0.02
Construction	-0.35	(0.38)	0.02	(0.43)	7	-0.03
Mining and Quarrying	-0.18	(0.24)	-1.20	(0.96)	7	-0.08
Agriculture, Forestry, Fishing	-0.17	(0.66)	3.06	(1.86)	7	-0.19
Transportation	0.16	(0.69)	0.98	(0.79)	7	-0.19
Financial Services	-0.16	(0.19)	0.075	(0.60)	7	-0.06

Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Source: World KLEMS, EU KLEMS.

Table 8: TFP Growth vs. Hours Growth (using U.S. value-added sectoral weights)

	Baseline	Time-varying weight
Constant	0.74***	0.82***
	(0.12)	(0.13)
Hours Growth	-0.37**	-0.38***
	(0.14)	(0.09)
Observations	14	14
Adjusted R^2	0.33	0.56

Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Source: Authors' calculations and World KLEMS, EU KLEMS.

Table 9: Using the Tax Wedge as an Instrument

Step 1 Regression

Hours Growth vs. Average Tax Wedge† by Period

Decades	1970-2007	1970s	1980s	1990s	2000-2007
Constant	-2.42**	-4.21**	-2.88*	-1.61	-0.23
	(1.00)	(1.82)	(1.35)	(1.19)	(1.33)
Average Tax Wedge	4.52**	6.15**	5.51**	3.23	1.82
	(1.60)	(2.69)	(2.14)	(1.96)	(2.21)
Observations	15	15	15	15	15
Adjusted R^2	0.33	0.23	0.29	0.11	-0.02

† Equal to (1- tax rate on labor income)/(1 + tax rate on consumption expenditures)

Step 2 Regression

TFP Growth vs. Predicted Hours Growth by Period

Decades	1970-2007	1970s	1980s	1990s	2000-2007
Constant	1.22***	1.73***	1.08***	0.75***	1.46
	(0.11)	(0.16)	(0.20)	(0.17)	(0.84)
Predicted Hours Growth	-0.71***	-0.83***	-0.37	-0.73*	-1.13
	(0.19)	(0.27)	(0.26)	(0.37)	(0.97)
Observations	15	15	15	15	15
Adjusted R^2	0.49	0.37	0.07	0.17	0.09

TFP Growth vs. Hours Growth and Average Tax Wedge

Periods	1970-2007	1970s	1980s	1990s	2000-2007
Constant	2.18***	3.55***	0.63	1.69*	1.59*
	(0.54)	(1.09)	(0.67)	(0.79)	(0.79)
Hours Growth	-0.31**	-0.40**	-0.53***	-0.14	-0.56***
	(0.12)	(0.14)	(0.12)	(0.17)	(0.17)
Average Tax Wedge	-1.79*	-2.66	0.86	-1.89	-1.03
	(0.90)	(1.60)	(1.11)	(1.34)	(1.35)
Observations	15	15	15	15	15
Adjusted R^2	0.64	0.60	0.63	0.14	0.46

Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Source: Authors' calculations using TED and McDaniel (2007) datasets.

Table 10: Using Population Growth as an Instrument

Hours Growth vs. Population Growth by Decade

Decades	1970-2007	1970s	1980s	1990s	2000-2007
Constant	-0.55***	-1.31***	-0.15	-0.27	0.12
	(0.16)	(0.28)	(0.23)	(0.31)	(0.17)
Population Growth	1.80***	1.96***	1.58***	1.22**	1.58***
	(0.24)	(0.36)	(0.38)	(0.46)	(0.27)
Observations	20	20	20	20	20
Adjusted R^2	0.75	0.61	0.46	0.24	0.64

Step 2 Regression

TFP Growth vs. Predicted Hours Growth by Decade

Decades	1970-2007	1970s	1980s	1990s	2000-2007
Constant	1.07***	1.67***	0.97***	0.53**	0.90***
	(0.11)	(0.16)	(0.18)	(0.20)	(0.28)
Predicted Hours Growth	-0.47***	-0.52**	-0.34	-0.02	-0.62**
	(0.15)	(0.20)	(0.21)	(0.34)	(0.25)
Observations	20	20	20	20	20
Adjusted R^2	0.33	0.24	0.07	-0.06	0.21

TFP Growth vs. Hours Growth and Population Growth

Decade	1970-2007	1970s	1980s	1990s	2000-2007
Constant	1.03***	1.52***	0.94***	0.47	0.90***
	(0.21)	(0.39)	(0.18)	(0.28)	(0.24)
Hours Growth	-0.53**	-0.63***	-0.48**	-0.25	-0.65*
	(0.24)	(0.22)	(0.18)	(0.21)	(0.33)
Population Growth	0.10	0.22	0.22	0.28	0.04
	(0.49)	(0.54)	(0.41)	(0.48)	(0.63)
Observations	20	20	20	20	20
Adjusted R^2	0.45	0.46	0.31	-0.03	0.32

Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Source: Authors' calculations using TED and United Nation datasets.

Table 11: Using the Tax Wedge as an Instrument

Step 1 Regression

Hours Growth vs. Average Tax Wedge† by Period

Decades	1970-2007	1970s	1980s	1990s	2000-2007
Constant	-2.42**	-4.21**	-2.88*	-1.61	-0.23
	(1.00)	(1.82)	(1.35)	(1.19)	(1.32)
Average Tax Wedge	4.52**	6.15**	5.51**	3.23	1.82
	(1.60)	(2.69)	(2.14)	(1.96)	(2.21)
Observations	15	15	15	15	15
Adjusted R^2	0.33	0.23	0.29	0.11	-0.02

† Equal to (1- tax rate on labor income)/(1 + tax rate on consumption expenditures)

Step 2 Regression

Labor Productivity per Hour vs. Predicted Hours Growth by Period

Decades	1970-2007	1970s	1980s	1990s	2000-2007
Constant	2.60***	3.59***	2.19***	2.11***	2.19**
	(0.20)	(0.32)	(0.35)	(0.19)	(0.79)
Predicted Hours	-0.63*	-0.78	-0.27	-0.60	-0.64
	(0.35)	(0.56)	(0.46)	(0.43)	(0.92)
Observations	15	15	15	15	15
Adjusted R^2	0.14	0.06	-0.05	0.06	-0.04

Labor Productivity per Hour vs. Hours Growth and Average Tax Wedge

Periods	1970-2007	1970s	1980s	1990s	2000-2007
Constant	2.74**	3.75	0.22	2.53***	2.25**
	(1.02)	(2.37)	(1.12)	(0.81)	(0.88)
Hours Growth	-0.57**	-0.75**	-0.95***	-0.34*	-0.42**
	(0.24)	(0.30)	(0.20)	(0.18)	(0.18)
Average Tax Wedge	-0.28	-0.23	3.78*	-0.84	-0.40
	(1.72)	(3.49)	(1.87)	(1.38)	(1.50)
Observations	15	15	15	15	15
Adjusted R^2	0.37	0.32	0.61	0.22	0.21

Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Source: Authors' calculations using TED and McDaniel (2007) datasets.

Table 12: Using Population Growth as an Instrument

Step 1 Regression

Hours Growth vs. Population Growth by Decade

Decades	1970-2007	1970s	1980s	1990s	2000-2007
Constant	-0.55***	-1.31***	-0.15	-0.27	0.12
	(0.16)	(0.28)	(0.23)	(0.31)	(0.17)
Population Growth	1.80***	1.96***	1.58***	1.22**	1.58***
	(0.24)	(0.36)	(0.38)	(0.46)	(0.27)
Observations	20	20	20	20	20
Adjusted R^2	0.75	0.61	0.46	0.24	0.64

Step 2 Regression

Labor Productivity per Hour vs. Predicted Hours Growth by Decade

Decades	1970-2007	1970s	1980s	1990s	2000-2007
Constant	2.60***	3.65***	2.26***	2.05***	2.07***
	(0.16)	(0.31)	(0.27)	(0.18)	(0.28)
Predicted Hours Growth	-0.61***	-0.56	-0.52	-0.27	-0.50*
	(0.21)	(0.37)	(0.31)	(0.31)	(0.25)
Observations	20	20	20	20	20
Adjusted R^2	0.28	0.06	0.08	-0.01	0.13

Labor Productivity per Hour vs. Hours Growth and Population Growth

Decade	1970-2007	1970s	1980s	1990s	2000-2007
Constant	2.50***	2.78***	2.19***	2.02***	2.06***
	(0.28)	(0.71)	(0.21)	(0.23)	(0.26)
Hours Growth	-0.80**	-1.23***	-0.96***	-0.38**	-0.38
	(0.33)	(0.40)	(0.22)	(0.18)	(0.35)
Population Growth	0.35	1.31	0.69	0.13	-0.18
	(0.68)	(0.99)	(0.49)	(0.40)	(0.68)
Observations	20	20	20	20	20
Adjusted R^2	0.43	0.36	0.55	0.16	0.14

Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Source: Authors' calculations using TED and United Nations datasets.

Table 13a: Labor Productivity Growth vs. Hours Growth by Sector, 1980-2007 (OECD 14)

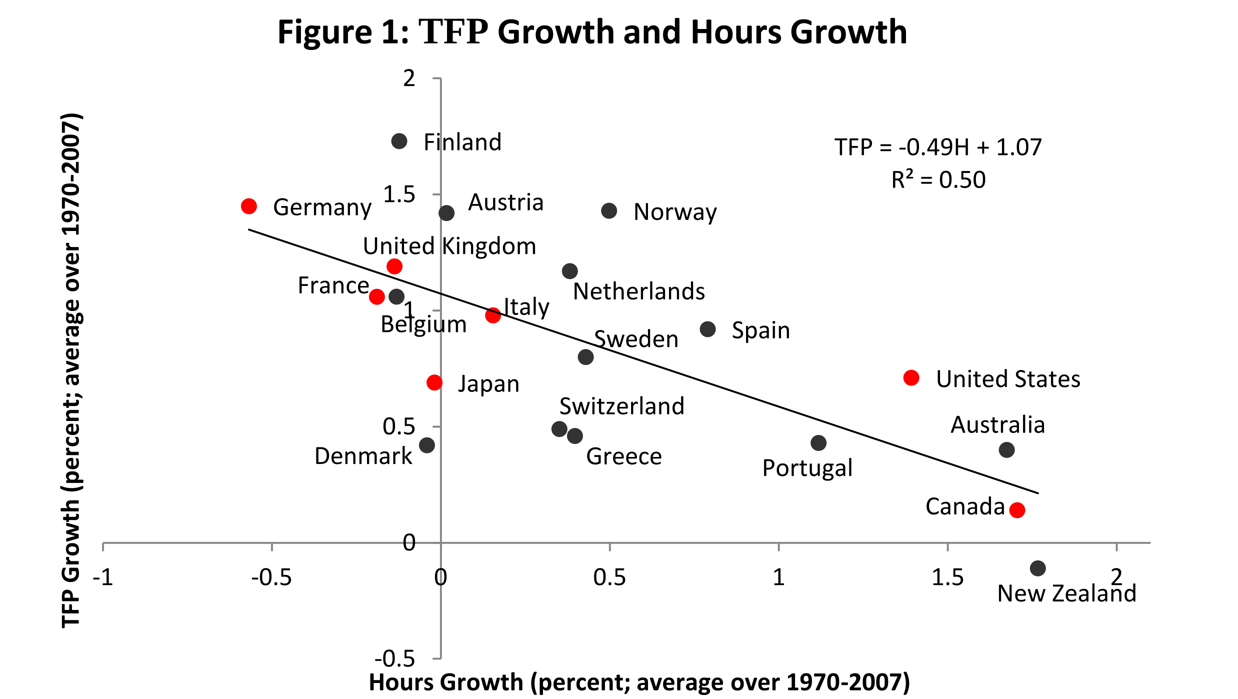
Industry	Coefficient		Constant		Observations	Adjusted R^2
Financial Services	-0.73***	(0.18)	3.42***	(0.64)	14	0.53
Transportation	-0.70***	(0.19)	2.38***	(0.21)	14	0.51
Total Economy	**-0.56*** **	**(0.16)**	**2.24*** **	**(0.14)**	**14**	**0.46**
Agriculture, Forestry, and Fishing	-0.54**	(0.19)	0.29	(0.50)	14	0.35
Wholesale and Retail	-0.53*	(0.27)	2.17***	(0.23)	14	0.18
Hotels and Restaurants	-0.51**	(0.20)	2.38***	(0.37)	14	0.30
Electricity	-0.49*	(0.23)	2.79***	(0.27)	14	0.21
Other Services	-0.32	(0.21)	1.82***	(0.33)	14	0.09
Manufacturing	-0.31	(0.24)	1.91***	(0.33)	14	0.05
Construction	-0.20	(0.12)	1.74***	(0.17)	14	0.11
Mining and Quarrying	0.10	(0.40)	4.03**	(1.50)	14	-0.08

Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1
Source: World KLEMS, EU KLEMS.

Table 13b: Labor Productivity Growth vs. Hours Growth by Sector, 1980-2007 (G7)

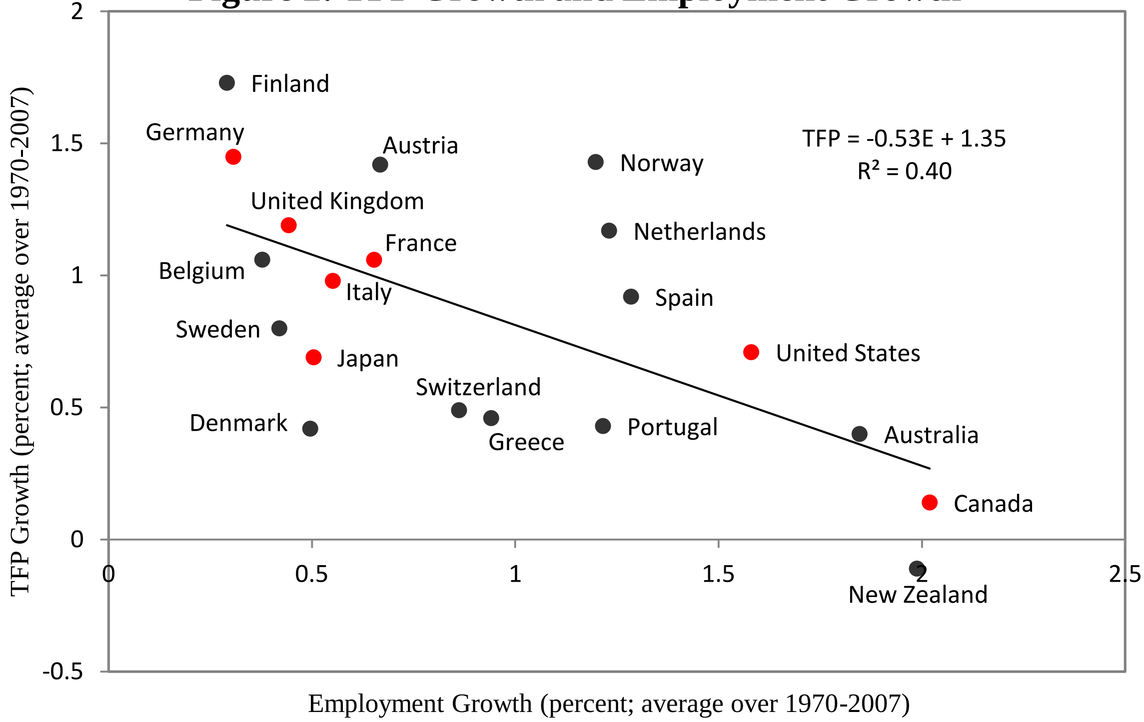
Industry	Coefficient		Constant		Observations	Adjusted R^2
Financial Services	-0.99**	(0.26)	4.19***	(0.81)	7	0.70
Wholesale and Retail	-0.86*	(0.39)	2.23***	(0.32)	7	0.38
Hotels and Restaurants	-0.84**	(0.27)	2.78***	(0.50)	7	0.59
Electricity	-0.76*	(0.33)	2.93***	(0.35)	7	0.42
Transportation	-0.75***	(0.18)	2.19***	(0.20)	7	0.74
Total Economy	-0.68**	(0.25)	2.29***	(0.19)	7	0.52
Other Services	-0.55	(0.40)	2.33***	(0.57)	7	0.12
Agriculture, Forestry, Fishing	-0.49	(0.26)	0.51	(0.72)	7	0.31
Manufacturing	-0.29	(0.26)	1.78***	(0.42)	7	0.04
Construction	-0.29	(0.26)	1.60***	(0.30)	7	0.03
Mining and Quarrying	-0.27	(0.34)	2.38	(1.36)	7	-0.07

Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1
Source: World KLEMS, EU KLEMS.



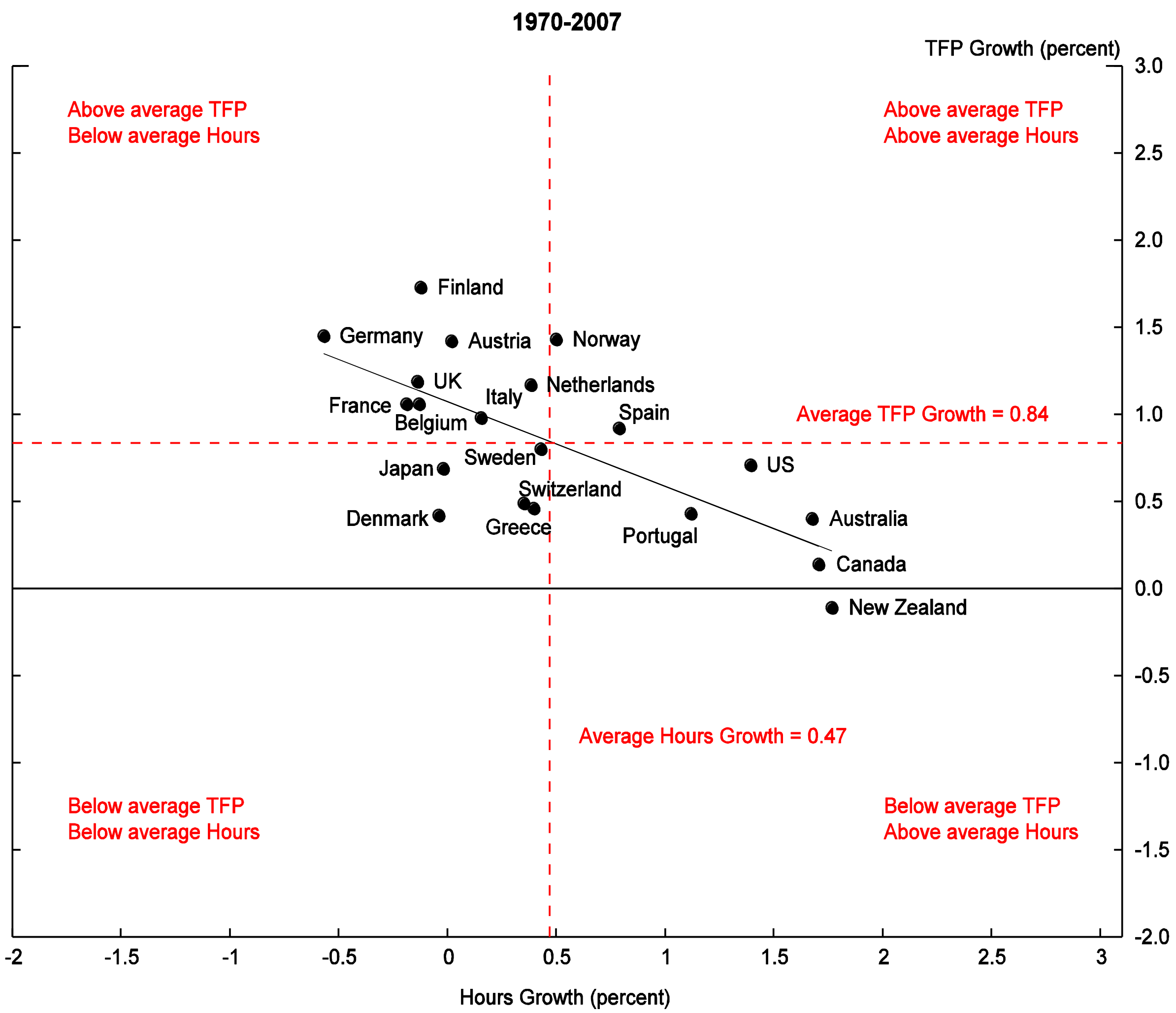
Source: Total Economy Database.

Figure 2: TFP Growth and Employment Growth



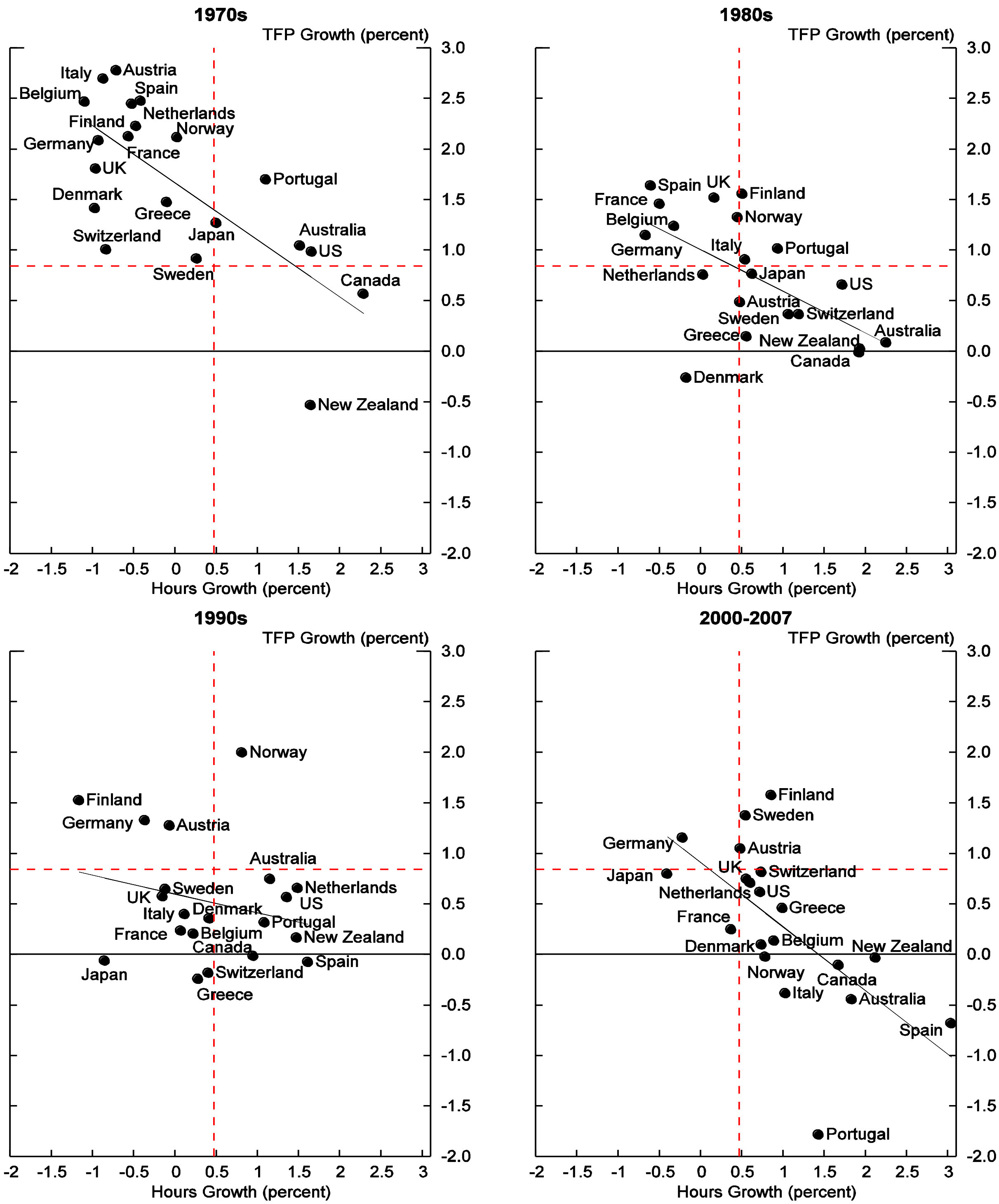
Source: Total Economy Database.

Figure 3a: TFP Growth and Hours Growth



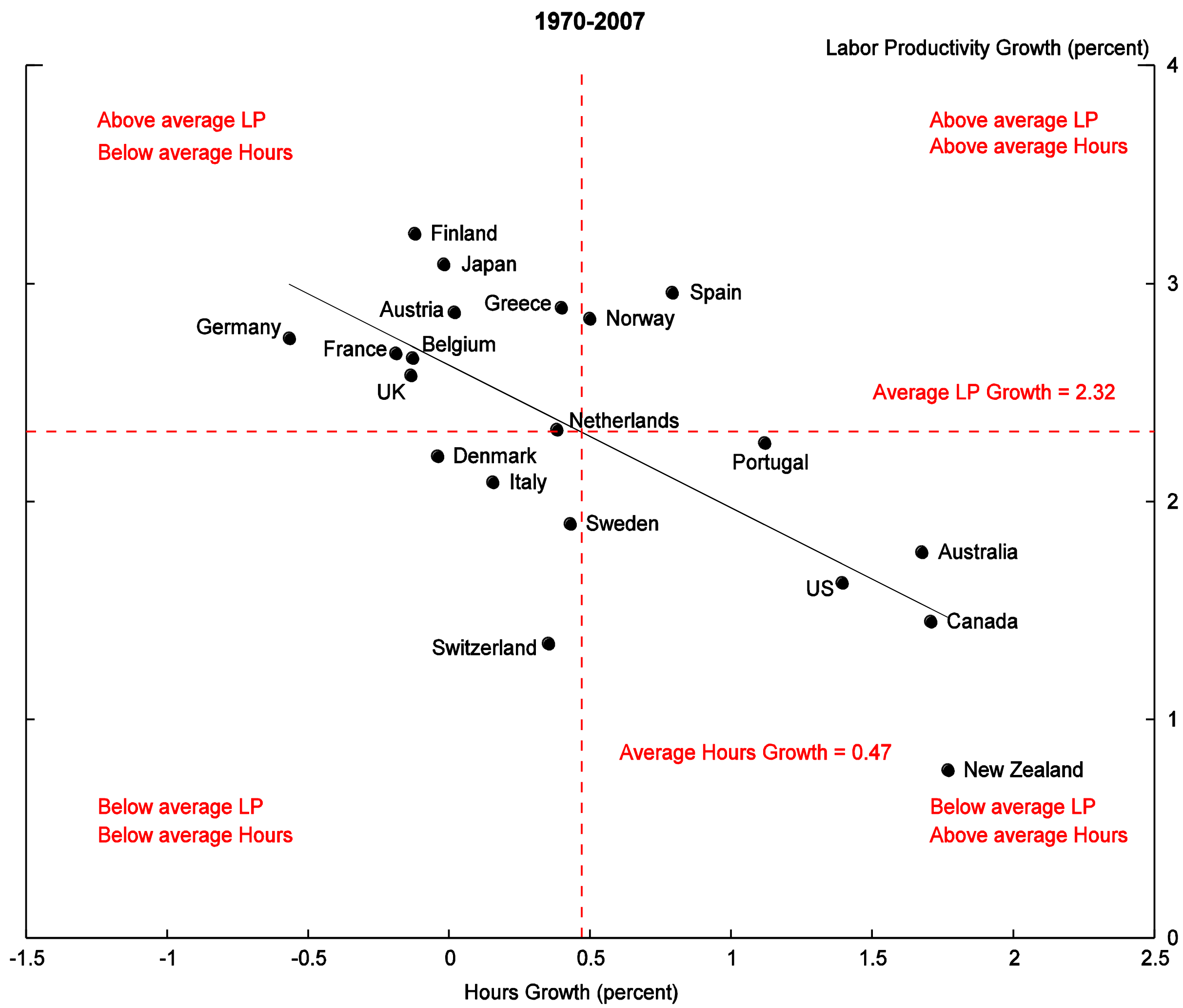
Dotted lines represent the averages over 1970-2007.

Figure 3b: TFP Growth and Hours Growth by Decade



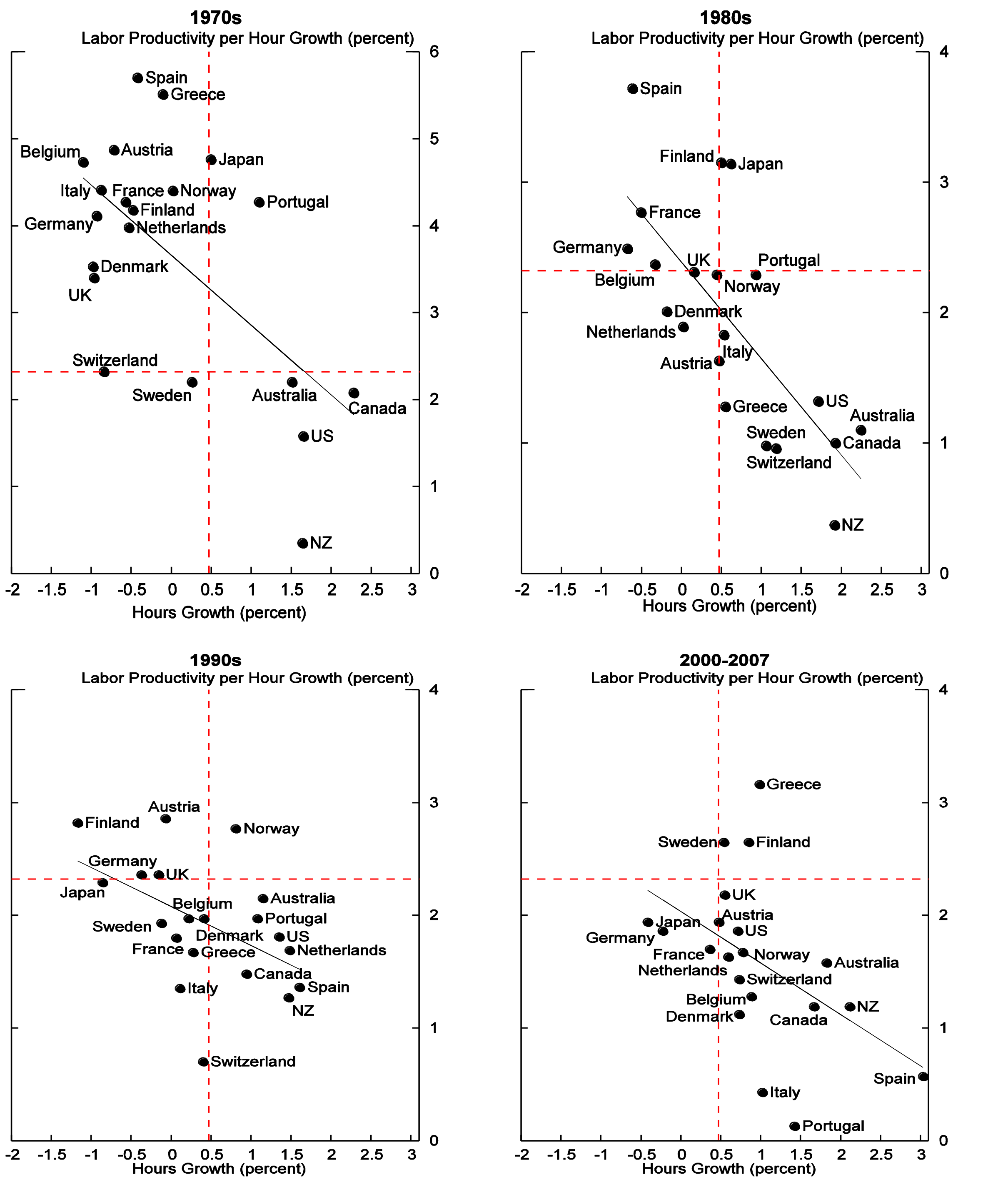
Dotted lines represent the averages over 1970-2007 on all charts.

Figure 4a: Labor Productivity per Hour and Hours Growth



Dotted lines represent the averages over 1970-2007.

Figure 4b: Labor Productivity per Hour and Hours Growth by Decade



Dotted lines represent the averages over 1970-2007 on all charts.