Productivity or Employment: Is it a Choice?

Andrea De Michelis
Marcello Estevão
Beth Anne Wilson*

December 21, 2012

PRELIMINARY

Abstract: Traditionally, shocks to total factor productivity (TFP) are considered exogenous and the response of employment is determined by the impact of the TFP shock on aggregate demand. In this paper, we approach the relationship between TFP and labor differently – raising the possibility that, in response to positive labor supply shocks, firms reduce efforts to increase labor efficiency – essentially picking a lower TFP/higher labor intensity point on the production frontier. In other words, we investigate whether TFP is endogenous. We present evidence using cross-country aggregate information pointing to a strong negative correlation between growth in TFP and labor inputs over the medium- to long-run. This result is robust to changes in datasets, across decades, and after controlling for industry composition. To address the question of causality, we use instruments to capture changes in hours worked that are independent of TFP and find that TFP growth falls following a pickup in hours growth. Our results, though preliminary, could have important policy implications. For instance, Canadian policymakers have been worried about the low productivity growth in their country. However, employment has grown more in Canada than in any other G-7 economy and low productivity growth may partly be a side-effect of its strong labor market performance. By the same token, in countries facing an aging population and a declining workforce, TFP may accelerate as firms find ways to utilize existing workers more effectively.

JEL Classifications: O33 (technological change, choices and consequences), E20 (general macro), J23 (employment determination)

*De Michelis and Wilson are economists in the Division of International Finance, Board of Governors of the Federal Reserve System, Washington, D.C. 20551 U.S.A. Estevão is an economist at the International Monetary Fund, Washington D.C. 20431 U.S.A. We thank Rebecca Spavins and Daniel Van Deusen for excellent research assistance, and Andrea Raffo for useful conversations. The views in this paper are solely the responsibility of the authors and should not be interpreted as reflecting the views of the Board of Governors of the Federal Reserve System or of any other person associated with the Federal Reserve System. Contact Author: Andrea De Michelis, andrea.demichelis@frb.gov, International Finance Division, 20th and C Streets, NW, Washington D.C. 20551.

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 productivity growth? In traditional economic theory, changes in TFP are a key driver of economic growth and, to a great extent, considered exogenous. In addition, employment growth is viewed as endogenous and determined by the type of technological change and the response of aggregate demand to the increase in productivity. However, the experience of Canada leads to questions the traditional view. More specifically, could TFP be endogenous? 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 total factor productivity. We begin by establishing a negative historical relationship between productivity 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 a process of reabsorbing the unemployed into jobs (Estevão, 2007, and Dew-Becker and Gordon, 2012).

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, and regulations and tax policies. We exploit these differences to assess the response of TFP growth to "exogenous" movements in hours of work. 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.

These initial results raise interesting and important policy questions. For instance, should countries with strong employment growth, such as Canada, worry less about their relatively weaker productivity? 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 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 and provides robustness checks. Section IV concludes.

II. Data

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 sources of the data 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 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.[1] 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 over the period 1970-2007.[2] Though data for a few additional countries are available, we restrict our analysis to a set of countries 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. 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 for TFP, employment, and hours have been exceptional, as documented in van Ark et al. (2011), our main results also hold if we extend our analysis beyond the Great Recession.

We also used data on population, taxes, and business cycle dates in our analysis (table 2). Population estimates come from TED and the United Nations (UN) Department of Economic and Social Affairs. Historical population projections, used to determine population growth surprises, were obtained from the UN's records at the Library of Congress. Tax data come from the 2010 update of McDaniel (2007). The dates for peaks and troughs of the business cycle are taken from the Economic Cycle Research Institute.

III. Results

A. Basic Result and Robustness

Using the data described above, we begin by calculating the simple long-run relationship between total factor productivity and labor inputs for the countries in our sample. Chart 1 shows a scatterplot of the annual percent change in total hours on the percent change in TFP for 20 OECD countries from 1970 to 2007 using TED. The fitted line through the country averages

[1] 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 et al. (2010), O'Mahony and Timmer (2009), and Timmer et al. (2010).

[2] 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, 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 a the total economy level.

shows a negative relationship, with a 1 percentage point increase in the growth rate of hours related to a 0.5 percent decline in TFP growth. The relationship holds closely when just the G-7 countries are included, shown in red, suggesting even 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 organize our analysis in per capita terms because, as we will argue later in the paper, population growth might 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 depress observed TFP, while a more intensive use of incumbent workers during the initial phase of expansions boost measured TFP (Comin, 2008, 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 of 40 years of data. Also, the results survive robustness tests, including the exclusion of some 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. For the 1990s, however, the relationship is less negative and notably weaker than in other decades, possibly reflecting a widespread slowdown in European TFP and a pick-up in U.S TFP growth.

Interestingly, 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.[3] 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 5a presents the industry results along with those of 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 most significant negative correlation followed by manufacturing and other services. At the other end of the range, there appears to be little relationship between TFP and hours in the transportation, mining, and construction industries. These results vary somewhat by country group and labor input, as can be seen, for example, in table 5b 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 and, on aggregate, is negative and significant.

The variance across sectors does suggest 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 this, 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 share for the United States by year. The results in table 6 show that holding sectoral composition fixed across country does not change the size and increases the statistical significance of the correlation. This result implies that the difference in the ratio of TFP growth to hours growth across countries reflects within-industry differences across countries rather than variances in industry concentration, at least at the level of disaggregation considered in our analysis.[4]

Returning to our scatterplot of TFP and hours growth for the full time period, 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 but below average hours

[3] The 14 countries are comprised of 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.

[4] For a smaller set of countries, using the EU KLEMS database only, we have also conducted a similar exercise using more disaggregated sectors (with 28 sectors rather than 10). We still find that the negative relation holds and the size of the coefficient does not significantly change.

growth. In contrast, countries, primarily outside Europe, such as Canada and the United States have below average TFP growth 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 in the European countries, even Germany, toward greater employment growth and weaker TFP growth over time. Increased labor utilization and reduced labor productivity in Europe has been well-documented and has been partly attributed to policies to liberalize labor markets, reducing labor costs to the firm and disincentives to work.[5]

B. Causality

The results above suggest a robust negative relationship between TFP growth and hours 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 the labor input in our baseline regressions.

First, we consider the role of taxes. There is a large literature that shows 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 demand and supply of labor. Ohanian, Raffo and Rogerson (2008) find that the differences in the tax wedge – a broad measure of taxes that encompasses taxes on income, payroll and consumption – account for much of the variance in hours worked across countries and over time.[6] However, labor taxes should not directly affect the growth of TFP. With this in

[5] See Jackman, Layard, and Nickell (2005).

[6] More formally, the tax wedge 1-τ_t is defined as:

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

mind, we calculate the average tax wedge for each country and use the measure 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. Step 1 regression in table 7 shows that the tax wedge is a good predictor of hours worked. We find that a highly significant coefficient on hours growth of about the same size as in the baseline OLS regression (table 3).[7] 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 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 an independent effect – though significant only at the 10 percent level – for the full sample period of 1970-2007, which may invalidate it as an instrument for hours of work in the baseline regression. It is not clear why labor taxes should affect the growth rate of TFP; it may be that our tax wedge variable is capturing taxes that affect the firm's choice of capital or labor efficiency independent of the cost of labor.

We then turn to population growth. Demographics has long been understood to be an important driver of labor supply; as such, firms located in countries with faster population growth may choose more hours independent of the technology available to them. However, population growth should not be linked to changes in total factor productivity. The step 1 results in table 8 indicate that the population is a good predictor of hours. In step 2, we generally find a negative coefficient on hours growth, although it is smaller (in absolute value) than in the baseline OLS regression (table 3) using the TED data. In addition, as seen in the third table, 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.

All told, we find some 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

---

where τ_{ht} stands for labor income (including payroll) tax and τ_{ct} for consumption tax. Ohanian, Raffo and Rogerson (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.

[7] Data on the tax wedge for the 1970-2007 period is available for only 15 of the 21 OECD countries earlier considered.

workers for more hours while stressing efficiency less. In addition, preliminary results (not shown in this version of the paper) indicate that positive population growth surprises also result into more hours and less TFP. The evidence from taxes, however, is more mixed. Surely, more research needs to be done to determine the direction of causality and the reasons behind it. For example, we plan to investigate the importance of institutional settings following the approach used in Dew-Becker and Gordon (2012) to investigate the role of labor market changes in the post-1995 slowdown of European labor productivity (not TFP).

IV. 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.[8] 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. 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, Eichenbaum, and Rubello, 1995). Other more related work to ours often finds a short-run to medium-run negative relationship between hours and labor productivity (not TFP) suggesting that sometimes aggregate demand or investment may not adjust or adjust quickly enough to bring labor productivity growth back to previous rates.[9]

[8] See for example, Acemoglu, Antras, and Helpman (2007) or Holmes and Schmitz (2001).

[9] 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, leaving (so far) a permanent mark on labor productivity.

The results in this paper tell a somewhat different story. Although still preliminary and suggestive, the long-run negative correlation we find between TFP growth and hours growth raises questions about how determinative 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, Hobijn, and Rovito, 2006) suggests that other factors besides TFP 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 hours or labor endowment. However, our preliminary results using instrumental variables 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: availability of inputs. This would be particularly true if increasing the efficiency of labor utilization were costly, which seems to be a reasonable assumption. Capturing these features in a model would be a clear next step for further research.

These results also suggest that for countries, like Canada, close to the technological frontier with good institutions and 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.

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 efficiency at the expense of hours may result in increased unemployment and loss of income for workers.

Bibliography

Acemoglu, Daron, Pol Antras, and Elhanan Helpman (2007). “Contracts and technology adoption,” American Economic Review, 97, pp. 916–43.

Basu, Susantu (1996). “Procyclical productivity: increasing returns or cyclical utilization?” Quarterly Journal of Economics, 111, pp. 719–51.

Blanchard, Olivier (1997). “The Medium Run,” Brookings Paper on Economic Activity, vol. 2, pp. 89–158.

Burnside, Craig, Martin Eichenbaum, and Sergio Rebelo (1995). “Capital utilization and returns to scale,” in NBER Macroeconomics Annual, eds. B.S. Bernanke and J.J. Rotemberg. Cambridge, MA: MIT Press.

Chen, Vivian, Ben Cheng, Gad Levanon, and Bart van Ark. (2011). “Performance 2011: Productivity, Employment, and Growth in the World's Economies,” The Conference Board, Report Number R-1475-11-RR.

Comin, Diego (2008). “total factor productivity,” The New Palgrave Dictionary of Economics. Second Edition, eds. Steven N. Durlauf and Lawrence E. Blume, Palgrave Macmillan.

Dew-Becker, Ian and Robert J. Gordon (2012). “The Role of Labor Market Changes in the Slowdown of European Productivity Growth,” Review of Economics and Institutions, 3(2), Article 1, pp. 1–45.

Estevão, Marcello (2007). “Structural Changes and Labor Productivity Slowdown in the Euro Area,” Ensayos, vol. 25, no. 53, pp. 336–367.

Holmes, Thomas J., and James A. Schmitz, Jr. (2001). “A Gain from Trade: from Unproductive to Productive Entrepreneurship,” Journal of Monetary Economics, vol. 47, pp. 417–46.

Jackman, Richard, Richard Layard, and Stephen Nickell (2005). *Unemployment: Macroeconomic Performance and the Labour Market*. New York, NY: Oxford University Press.

Jorgenson, Dale W., Mun Ho, and Jon Samuels (2010). “New Data on U.S. Productivity Growth by Industry,” mimeo, Harvard University.

McDaniel, Cara (2007). “Average tax rates on consumption, investment, labor and capital in the OECD 1950-2003,” mimeo, University of Arizona.

Ohanian, Lee E., Andrea Raffo, and Richard Rogerson (2008). “Long-Term Changes in Labor Supply and Taxes: Evidence from OECD Countries 1956-2004,” Journal of Monetary Economics, vol. 55, no. 8, pp. 1353–1362.

O’Mahony, Mary and Marcel P. Timmer (2009). “Output, Input and Productivity Measures at the Industry Level: the EU KLEMS Database,” Economic Journal, 119(538), F374-F403.

Prescott, Edward C., (2004). “Why Do Americans Work So Much More than Europeans?,” Federal Reserve Bank of Minneapolis Quarterly Review, vol. 28, no. 1, July, pp. 2–13.

Solow, Robert (1956). “A contribution to the theory of economic growth,” Quarterly Journal of Economics, vol. 70(1), pp. 65–94.

Timmer, Marcel P., Robert Inklaar, Mary O'Mahony, and Bart van Ark (2010). *Economic Growth in Europe*. Cambridge: United Kingdom: Cambridge University Press.

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	Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Italy, Japan, Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, United Kingdom, United States	1956-2011
		TFP	Same Countries	1970-2011
EU KLEMS	Yes	Total Employment Total Hours Worked	Australia, Belgium, Denmark, Finland, Japan, Netherlands	1970-2007
		TFP	Australia, Belgium, Denmark, Finland, Japan, Netherlands	1970-2007
World KLEMS	Yes	Total Employment Total Hours Worked	Austria, Canada, France, Germany, Italy, Spain, United Kingdom, United States	1970-2010, but ranges widely by country
		TFP	Same Countries	1970-2010, but ranges widely by country
AMECO	No	Total Employment	Canada, France, Germany, Italy, Japan, United Kingdom, United States	1960-2013
		TFP	Same Countries	1960-2013

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 5a: 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 5b: 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 6: 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 7: 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 8: 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

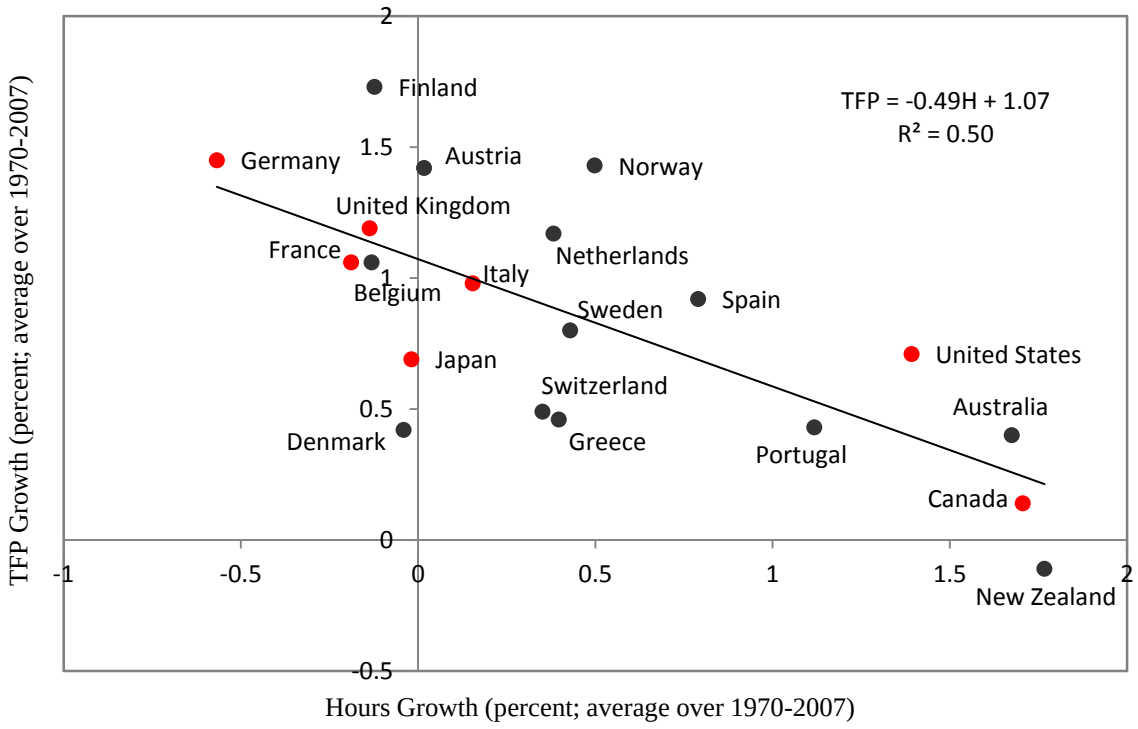
TFP Growth vs. Hours Growth and Population Growth

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

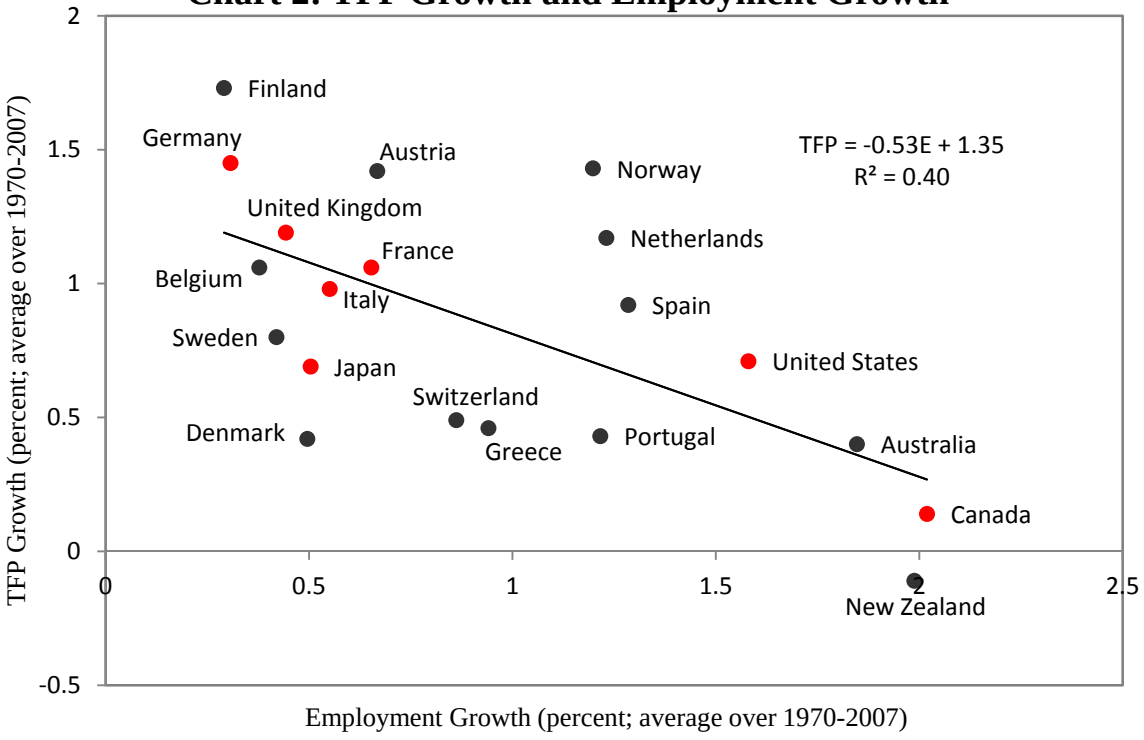
Source: Authors' calculations using TED and United Nation datasets.

Chart 1: TFP Growth and Hours Growth



Source: Total Economy Database.

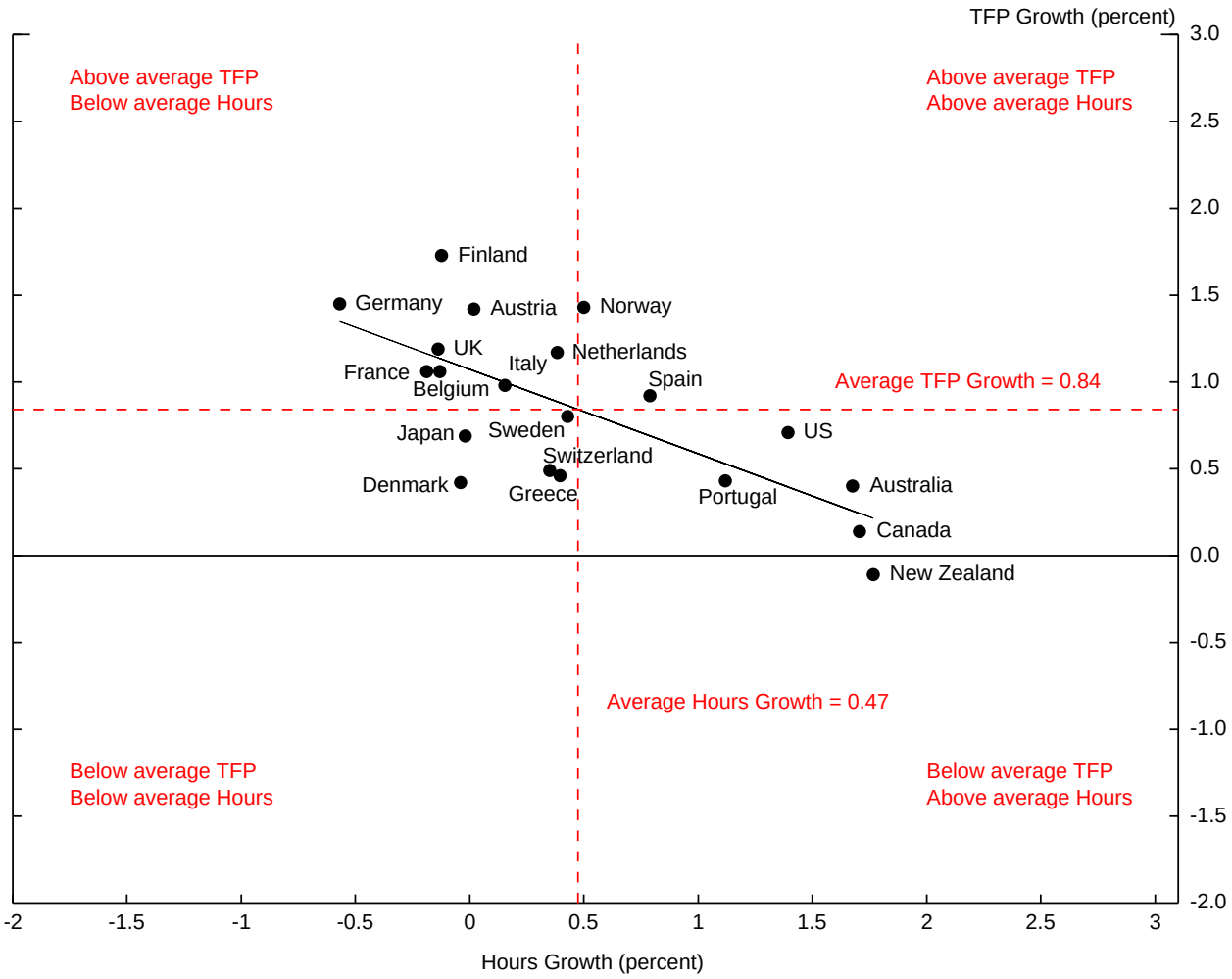
Chart 2: TFP Growth and Employment Growth



Source: Total Economy Database.

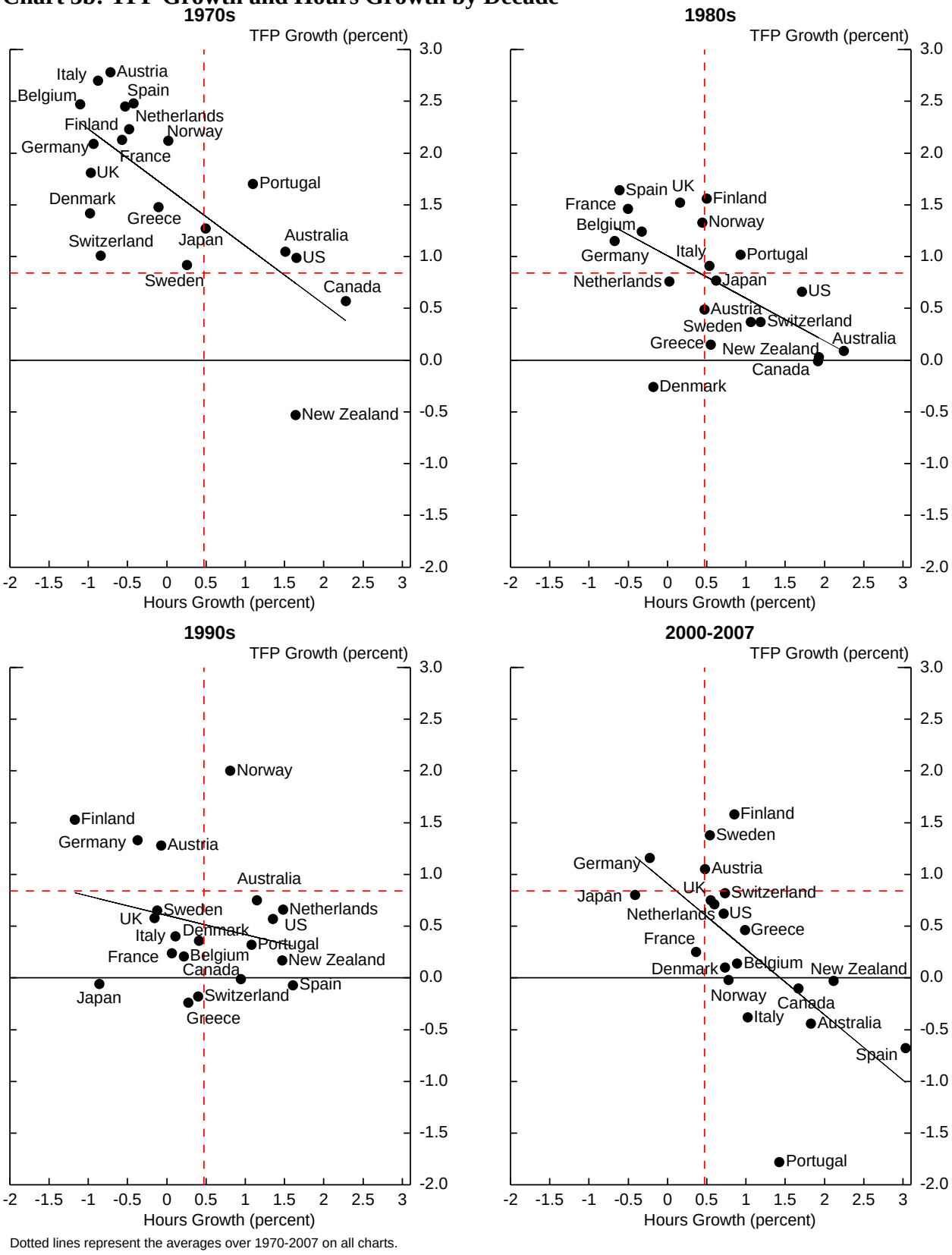
Chart 3a: TFP Growth and Hours Growth

1970-2007



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

Chart 3b: TFP Growth and Hours Growth by Decade



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