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ON DYNAMIC ECONOMIES WITH NON-STATIONARY LABOUR-INTENSIVE MARGIN

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Abstract

We show that in infinite horizon macroeconomic models with not-stationary labour-intensive margin (i) long-term growth can be driven by the accumulation of productive factors when labour efficiency is declining; (ii) some "paradoxical" equilibrium paths can emerge with either negative long-term interest rates when the rate of technical progress is positive and economic agents discount the future or positive interest rates when the rate of technical progress is negative and economic agents capitalize on the present; and (iii) given a long-term rate of variation in the labour-intensive margin, the transversality condition limits the range of values of the elasticity of substitution and the Frisch elasticity compatible with a balanced growth path.

Keywords: Interest rate; growth; technical change; discount factor; intertemporal elasticity of substitution; Frisch elasticity; tranversality condition; labour-intensive margin.

JEL classification: E21, J22, O11, O40

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1 Introduction

Economies experiencing long-run growth with a fall in the labour-intensive margin have recently received attention. The constancy of hours worked per capita during the post-war period in the US is exceptional in US history itself, as well as relative to the rest of the world. Boppart and Krusell (2020) (BK) report that across countries and historically, hours worked per capita fall steadily by a little below 0.5% per year and Jones (2016) includes the decline in hours worked per employee among the fundamental facts of economic growth. The third column of Table 1 shows the average annual gross rate of change in hours worked per capita for 69 countries. Table 1 shows that hours worked per capita have been on a slight downward trend in most developed countries since 1950.

The non-stationarity of the labour-intensive margin has led to the need for changes in the standard balanced growth theory in order to make the theory consistent with the data, at least over long periods of time. BK describe the only family of utility functions that allows to reconcile output growing at a stable rate with hours worked per capita changing over time at a constant rate along a balanced path (BGP), and discuss the properties of some utility functions belonging to this family that may be useful in applications. In particular, for a MaCurdy (1981)'s utility function, they restrict the values of the intertemporal elasticity of substitution and the Frisch elasticity consistent with a change rate in the labour-intensive margin along a balanced growth path.

The purpose of this paper is point out some novel implications of the growth theory reconciling long-run growth rate of output per capita and non-stationary labour-intensive margin.

First, the incorporation of the BK family of utility functions into exogenous growth theory implies that the long-run growth rate is not exclusively determined by technological factors, but also by preference characteristics.[1] As we show in this paper, this means that factor accumulation can be the engine of growth in situations of technical regress. The reason is that the income effect caused by the technical reversal could make the labour-intensive margin grow quickly enough to offset it.

In the absence of technological progress and increasing returns to scale, per-

[1] In this sense, an infinite-horizon dynamic macroeconomic model with a BK utility function is similar to the semi-endogenous growth model developed by Jones (1995), in which the long-run growth rate depends on technological and preferences parameters, but it is not influenced by economic policies.

petual growth is not possible in standard exogenous growth models such as the Solow growth model (see Solow, 1957) or dynamic macroeconomic models with either overlapping generations or an infinite life horizon in which utility functions of the family identified by King et al. (1988) (KPR) are assumed and, consequently, the labour-intensive margin remains constant. In these models, the long-run growth rate of output per capita is equal to the rate of labour-augmenting technical progress and then the long-run growth rate only can be positive if the rate of labour-augmenting technical change is also positive.

An implication of the growth theory with BK preferences is that technical regression occurs if and only if the growth rate of the labour-intensive margin is higher than the growth rate of output per capita. As reported by BK, hours worked per capita have historically declined in the United States and other advanced economies, which rules out technical regress as output per capita has grown. However, other measures of the labour-intensive margin can be used. In particular, we also consider a measure of the labour-intensive margin that adjusts for the quality of labour. Using a sample of 69 countries, we compare the growth rates of output per capita, hours per capita and quality-adjusted hours per capita. Our conclusion is that technical regression is empirically not very plausible.

Second, unlike the preferences mostly used in dynamic macroeconomic models (the KPR family), under BK preferences, the interest rate can be negative even when the rate of technical change is positive and the intertemporal discount factor is lower than one, and instead it can be positive even if the rate of technical change is negative and the intertemporal discount factor is higher than one. However, in dynamic infinite-horizon macroeconomic models with KPR preferences, and hence where the labour-intensive margin is constant in the long run, Kocherlakota's (1990) result avoids these possibilities. Kocherlakota (1990) shows that in these models, if the long-run growth rate is positive, then the long-run interest rate is positive even if the representative agent has a discount factor greater than one. Since in these models the long-run growth rate is equal to the rate of labour-augmenting technical progress, it follows that if the latter is positive, then the long-run interest rate also must be positive. Kocherlakota's (1990) result is also valid for BK economies in which labour-intensive margin is non-stationary, but these economies can have a positive (resp. negative) long-run growth rate if the rate of labour-augmenting technical progress is negative (resp. positive). This can lead to the paradoxical results mentioned above.

Finally, for a MaCurdy (1981)'s utility function, we show that the transversality condition (see Michel, 1982) limits the range of values of the intertemporal elasticity of substitution and the Frisch elasticity compatible with a Balanced Growth Path (BGP) along which the labour-intensive margin is non-stationary even more than the range considered by BK.

This paper is organized as follows. Section 2 establishes the long-run relationship between the rates of labour-augmenting technical progress and economic growth. Section 3 analyses the long-run relationship between the rate of technical progress and the interest rate. Section 4 establishes the restrictions that the calibration of an infinite-horizon dynamic macroeconomic model imposes on the intertemporal elasticity of substitution and the Frisch elasticity when a MaCurdy (1981)'s utility function function is assumed. Finally, Section 5 concludes.

2 Growth and technical change

The per capita resource constraint of the neoclassical growth model is

$$\eta k_{t+1} = y_t + (1-\delta)k_t - c_t,$$

where k is capital per capita, y is output per capita, c is consumption per capita, $\eta \geq 0$ is the gross rate of population growth and $0 < \delta < 1$ is the depreciation rate. According to the resource constraint, if both the ratio of consumption to capital, c/k, and the ratio of output to capital, y/k, are constant, then the gross growth rate of capital per capita is constant and equal to the gross growth rates of capital per capita and consumption per capita,

$$g_k = g_y = g_c = g,$$

where g is the gross growth rate of the variables per capita along the BGP.

In the neoclassical growth model, output per capita is produced using capital and labour according to a homogeneous neoclassical function of degree 1,

$$y_t = F(k_t, \gamma^t h_t),$$

where $\gamma \geq 0$ is the gross rate of labour-augmenting technological change and h_t is the labour-intensive margin. It follows that the ratio of output to capital, y/k, is constant if $\gamma^t h_t/k_t$ is constant. Therefore,

$$g = g_h \gamma, \tag{1}$$

where g_h is the gross growth rate of labour effort along a BGP.

The BK intertemporal utility function of the representative household is

$$U = \sum_{t=0}^{\infty} \eta^t \beta^t \frac{\left(c_t \cdot v\left(h_t\, c_t^{\nu/(1-\nu)}\right)\right)^{1-\sigma}}{1-\sigma}, \tag{2}$$

where v is a twice continuously differentiable function, $\beta \geq 0$ is the discount factor, $\sigma > 0$ and $\sigma \neq 1$. The KPR utility function, which is often used in the dynamic macroeconomic models, is a particular case of the BK utility function in which $\nu = 0$.

The BK utility function, U, is consistent with a BGP along which $h_t c_t^{\nu/(1-\nu)}$ is constant, which together with (1) implies that

$$g = \gamma^{1-\nu}, \tag{3}$$

and

$$g_h = \gamma^{-\nu}. \tag{4}$$

If $\nu \neq 0$, then along a BGP the labour-intensive margin persistently increases or decreases. However, if $\nu = 0$, then the KPR utility function results and, along a BGP, the labour-intensive margin remains constant ($g_h = 0$), while the growth rate of output per capita equals the rate of labour-augmenting technical change ($g = \gamma$). In this case, just like in the Solow growth model, the long-run growth is supported by a positive rate of technical change.

The following proposition establishes the relationship between the rate of labour-augmenting technical change and the growth rates of output per capita and the labour-intensive margin.

Proposition 1. *If $\gamma > 1$ (resp. $\gamma < 1$), then*

1. *$g > 1$ (resp. $g < 1$) if and only if $\nu < 1$ and, for any γ, $g = 1$ if $\nu = 1$.*
2. *$g_h < 1$ (resp. $g_h > 1$) if and only if $\nu > 0$ and, for any γ, $g_h = 1$ if $\nu = 0$.*

Proof. Proposition 1 follows from (3) and (4). □

Proposition 1 highlights that long-run growth does need to be driven by technical progress and can be supported by factor accumulation when labour efficiency declines. If $\nu > 1$, as the production function exhibits constant returns to scale, the perpetual and simultaneous growth of capital per capita and the labour-intensive margin leads the long-run growth of output per capita. If $\nu > 0$, then the income effect is higher than the substitution effect and, when the labour efficiency declines, the labour-intensive margin increases. Moreover, if $\nu > 1$, then the income effect is large enough to lead the growth of the labour-intensive margin adjusted by its efficiency, $\gamma^t h_t$, which drives the accumulation of capital so that in the long run the ratio of adjusted labour-intensive margin to capital per capita, $\gamma^t h_t / k_t$, remains constant.[2]

Despite the possibility of perpetual growth in the presence of a technical reversal, empirically such a possibility seems rather unlikely. From (1), it follows that

$$\gamma > 1 \text{ (resp. } \gamma < 1) \text{ if and only if } g > g_h \text{ (resp. } g < g_h)$$

Fig. 1 presents the evolution of two measures of the labour-intensive margin in the United States from 1950 to 2019. One measure is the hours worked per capita and displays a slight decrease at a net annual rate around 0.3%. The other multiplies the hours worked per capita by a human capital index and displays a net annual growth rate of around 0.54%. The net annual growth rate of GDP per capita is around 1.8%, which implies that the net annual rate of technical progress is around 1.5%.

Fig. 2 summarises the data presented in Table 1 containing the gross annual rates of change of both measures of the labour-intensive margin together with the gross annual rate of change in GDP per capita for 69 countries.

Panel (a) in Fig. 2 illustrate that in only three countries (Venezuela, South Africa, and Trinidad and Tobago) do the gross annual rates of change in quality-adjusted hours worked per capita exceed the respective annual rates of change in GDP per capita. Only in Trinidad and Tobago, the annual growth rate of hours worked per capita was higher than the annual growth rate of GDP per capita (see panel (b) Fig. 2).

[2] BK rule out $\nu > 1$ because, as they argue, if there is technical progress, $\gamma > 1$, then in the long-run output per capita falls at the same time as wages rise. However, if $\gamma < 1$, then a value of $\nu > 1$ is consistent with the simultaneous long-run growth of output per capita and wages.

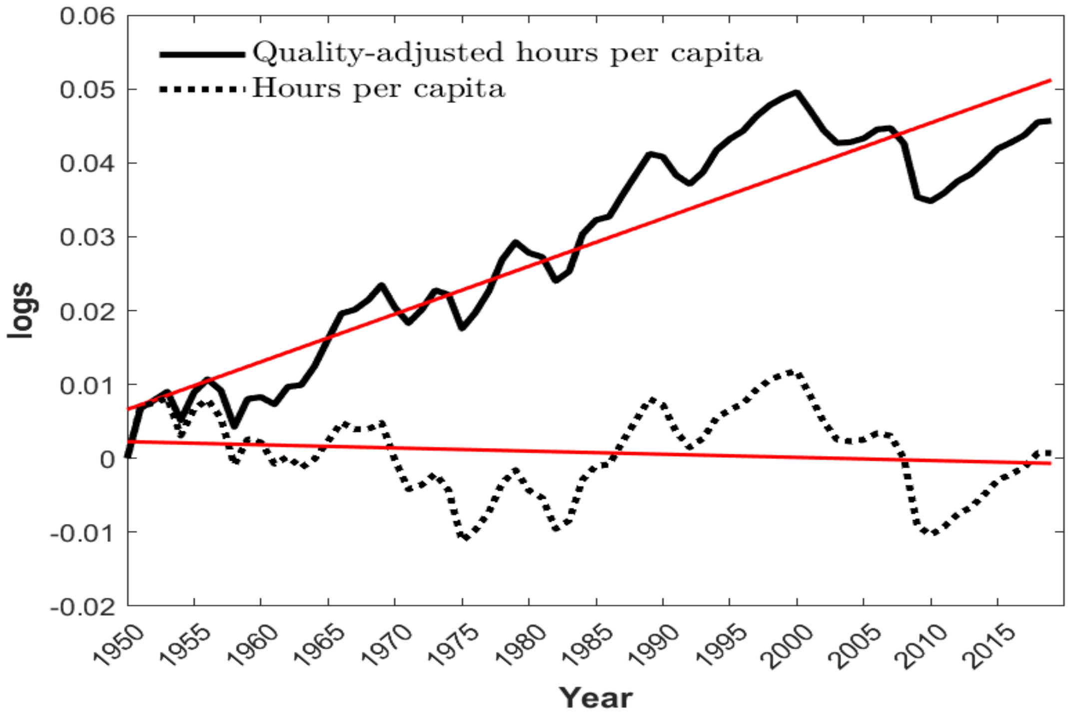
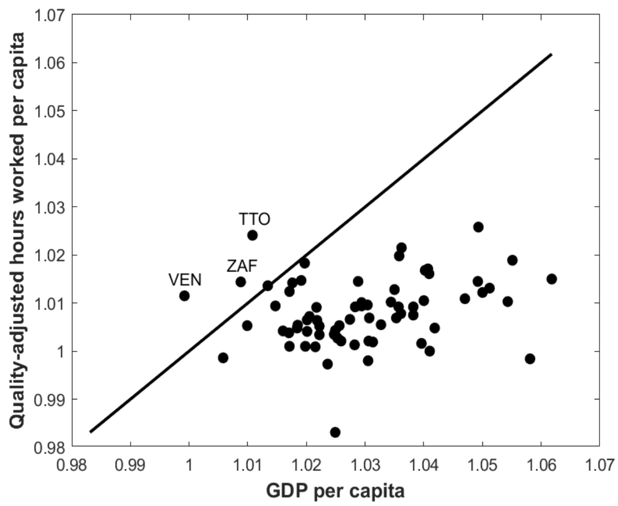
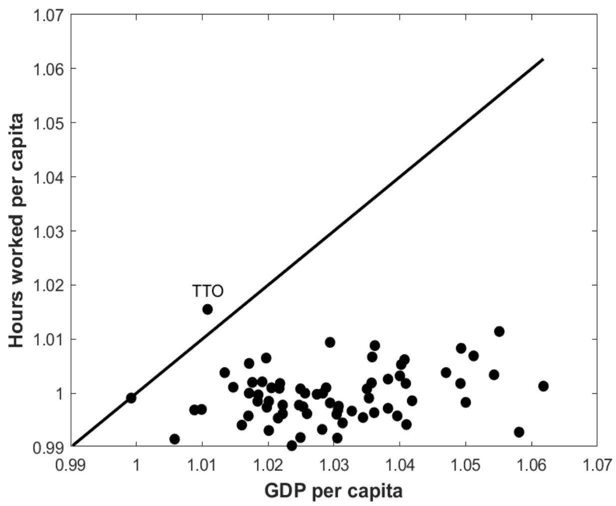


Fig. 1: Two measures of labour effort per capita in the United States.



(a) GDP vs. quality-adjusted hours worked.



(b) GDP vs. hours worked.

Fig. 2: Annual gross growth rates of GDP and labour-intensive margin.

Note: Venezuela (VEN), South Africa (ZAF), and Trinidad and Tobago (TTO). Hours per capita are average annual hours worked by persons engaged in production (**avh**) multiplied by number of persons engaged in production (**emp**) and divided by population aged 15-64. Quality hours per capita are hours per capita multiplied by the human capital index (**hc**). GDP per capita is output-side real GDP (**rgdpo**) divided by population. The gross annual rates of change are computed running a regression between years and the logs of the variables, and then the exponential of the estimated coefficient is computed. All variables are from Feenstra et al. (2015) (Penn World Table 10.01) execepting population aged 15-64 which is provided by United Nations (2024).

3 Interest rate, technical change and discount factor

For a BGP exists, it is necessary that U be finite. Therefore, the transversality condition implies that

$$\beta\eta g^{(1-\sigma)} < 1. \tag{5}$$

Along a BGP, the Euler condition—which characterizes the potential optimal consumption paths maximizing the intertemporal utility of the representative household—implies that

$$R = g^{\sigma}\beta^{-1}, \tag{6}$$

where R is the gross interest rate.

The following proposition states the relationship between the long-run-interest rate and the long-run growth rate.

Proposition 2.

(1) If $g > 1$, then $R > 1$ and (i) if also $\sigma < 1$, then $\beta < 1$, but (ii) if also $\beta > 1$, then $\sigma > 1$.

(2) If $R < 1$, then $g < 1$ and (i) if also $\sigma > 1$, then $\beta < 1$, but (ii) if also $\beta > 1$, then $\sigma < 1$.

Proof. Proposition 2 follows from (5) and (6). □

It follows from Proposition 2 that a negative long-run net interest rate can only arise in shrinking economies, whereas, as pointed out by Kocherlakota (1990), in growing economies the long-run interest rate will be positive even though the representative household has a discount factor greater than 1.

If a utility function belongs to the KPR family (the case where $\nu = 0$), then the long-run growth rate is equal to the rate of labour-augmenting technical change. Therefore, Proposition 2 implies that KPR economies with technical progress (i.e. when $\gamma > 1$) must have positive long-run net interest rates, which can only be negative under technical regress (i.e. when $\gamma < 1$).

However, considering (3), it follows that

$$\text{if } \nu > 1, \text{ then } g > 1 \text{ (resp. } g < 1) \text{ if and only if } \gamma < 1 \text{ (resp. } \gamma > 1).$$

Propositon 3 states the relationship between the rates of interest and technical change when $\nu > 1$.

Proposition 3. *If $\nu > 1$ and*

(1) if $\gamma < 1$, then $R > 1$ and (i) if also $\sigma < 1$, then $\beta < 1$, but (ii) if also $\beta > 1$, then $\sigma > 1$, or

(2) if $R < 1$, then $\gamma > 1$ and (i) if also $\sigma > 1$, then $\beta < 1$, but (ii) if also $\beta > 1$, then $\sigma < 1$.

Proof. Proposition 3 follows from Proposition 2 and (3). □

Proposition 3 implies that two paradoxical results, which KPR utility functions avoid, can arise with utility functions belonging to the BK family. In particular: (i) economies with a negative rate of technological change, $\gamma < 1$, and a discount rate higher than 1, $\beta > 1$, can have positive long-run interest rates, and (ii) economies with a positive rate of technological change, $\gamma > 1$, and a discount rate lower than 1, $\beta < 1$, can have negative long-run interest rates. In summary, if $\nu > 1$, negative long-run net interest rates can occur in economies with technical progress even if the discount factor is less than 1, while in economies with technical regress, they can be positive even if the discount factor is greater than 1.

4 Calibration

Boppart and Krusell (2020) discuss in detail the calibration of some utility functions of the BK family. In particular, they discuss the calibration of the MaCurdy (1981)'s utility function,

$$u(c,h) = c^{1-\sigma}/(1-\sigma) - h^{1+1/\theta}/1 + 1/\theta,$$

which is useful for quantitative exercise because they involve two parameters with clear economic interpretations: the intertemporal elasticity of substitution, $1/\sigma$, and the Frisch elasticity of the labour supply, θ.

The MaCurdy (1981)'s utility function can be rewritten as a utility function of the BK family (2) with

$$v(hc^{\frac{\nu}{1-\nu}}) = \left[1 - \frac{1-\sigma}{1+\frac{1}{\theta}}\left(hc^{\frac{\nu}{1-\nu}}\right)^{1+\frac{1}{\theta}}\right]^{\frac{1}{1-\sigma}},$$

being

$$\frac{\nu}{1-\nu} = \frac{\sigma-1}{1+\frac{1}{\theta}}$$

which, for any ν, implies the following relationship between the parameters determining the intertemporal elasticity of substitution and the Frisch elasticity (i.e. σ and θ),

$$\sigma = \frac{1}{1-\nu} + \frac{\nu}{1-\nu}\frac{1}{\theta} \tag{7}$$

This relationship is decreasing (resp, increasing) and with a lower (resp. upper) bound in $1/(1-\nu)$ if $0 < \nu < 1$ (resp. otherwise). It implies a constraint on the calibration of both parameters consistent with the respective rates of variation of output per capita and the labour-intensive margin, as shown by Boppart and Krusell (2020).

However, the transversality condition (5) imposes an additional constraint on the parameters. From (5) and (3), it follows that

$$\omega = \frac{\log \beta\eta}{\log \gamma} \begin{cases} < (1-\nu)(\sigma - 1) \text{ if } \gamma > 1 \\ \\ > (1-\nu)(\sigma - 1) \text{ if } \gamma < 1 \end{cases} \tag{8}$$

Proposition 4 follows from (7) and (8).

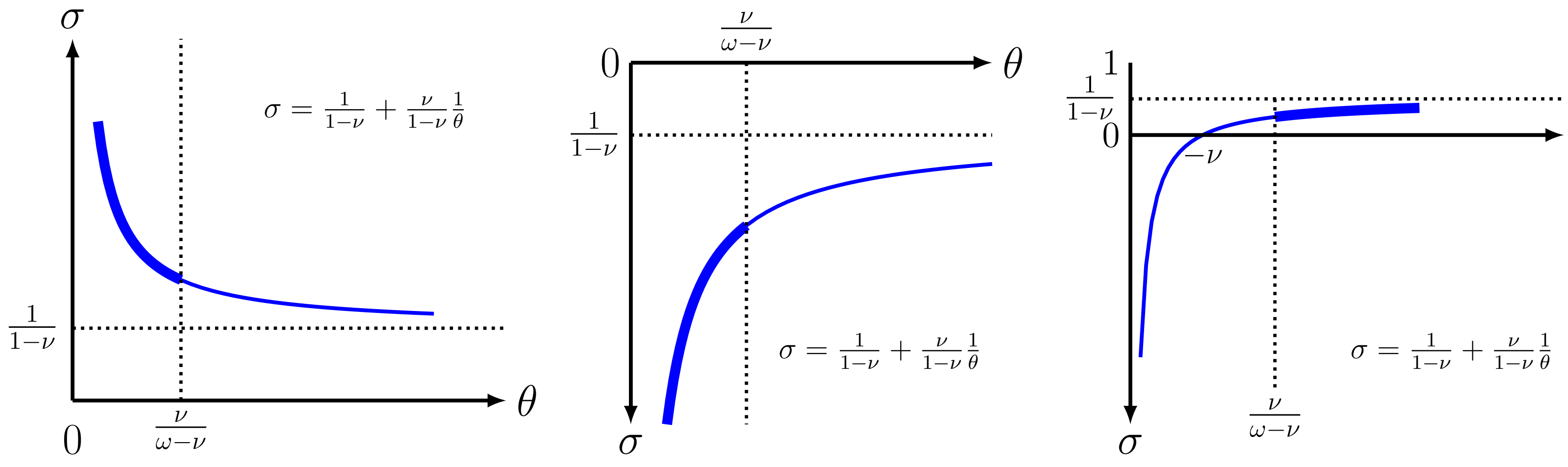
Proposition 4. *If $\gamma > 1$ (resp. $\gamma < 1$), the transversality condition (5) is satisfied if and only if*

(1) $\theta < \frac{\nu}{\omega-\nu}$ *if* $\omega > \nu > 0$ *(resp.* $0 > \nu > \omega$*).*

(2) $\theta > \frac{\nu}{\omega-\nu}$ *if* $0 > \nu > \omega$ *(resp.* $\omega > \nu > 0$*).*

If the rate of technological change is positive, then Proposition 4 imposes a lower bound on the Frisch elasticity if the rate of change in labour effort is negative and an upper bound if it is positive. However, if the rate of technological change is negative, then Proposition 4 imposes a upper bound on the Frisch elasticity if the rate of change in labour effort is negative and an lower bound if it is positive.

This bound is binding when $\beta\eta g_h$ is higher or lower than 1 depending on the value of ν. In summary, Proposition 4 limits the range of values that, satisfying condition (7), are compatible with the existence of an equilibrium path in infinite horizon macroeconomic models. Fig. 3 and Fig. 4 illustrate proposition 4.

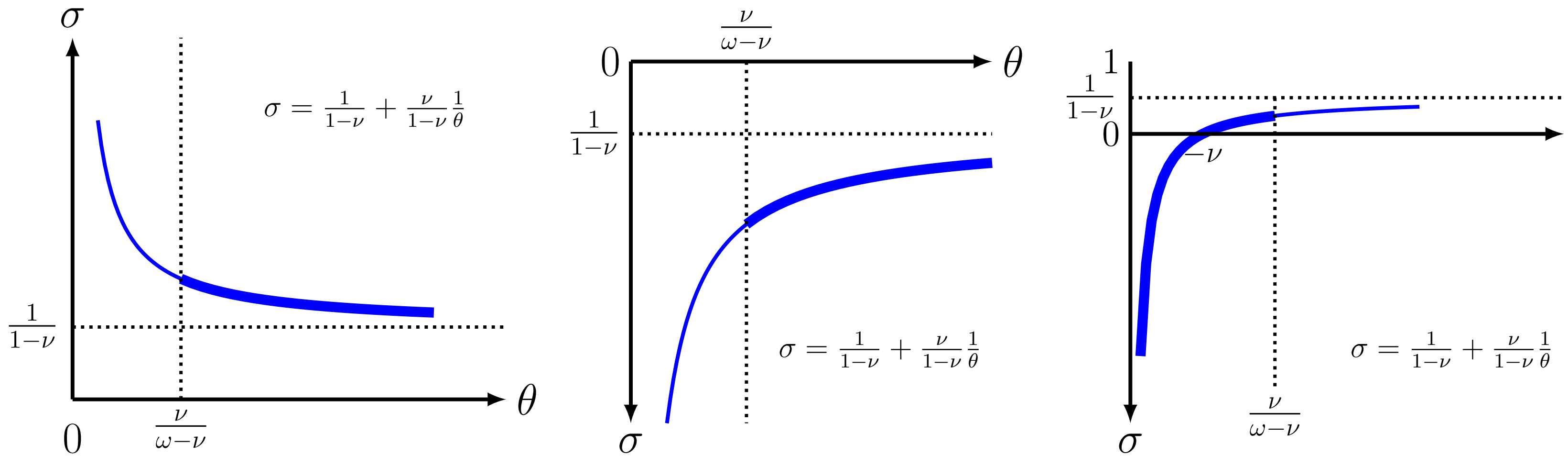


(a) $0 < \nu < 1$.

(b) $\nu > 1$.

(c) $\nu < 0$.

Fig. 3: Proposition 4 when $\gamma > 1$.



(a) $0 < \nu < 1$.

(b) $\nu > 1$.

(c) $\nu < 0$.

Fig. 4: Proposition 4 when $\gamma < 1$.

Note: The thicker line represents the combinations (σ, θ) values that, in addition to being admissible in the BK framework, are compatible with the existence of a BGP equilibrium.

In Fig. 5 we provide a numerical example of the value that the bound on the Frisch elasticity takes when $\gamma = 1.02$, $\beta = 0.989$, and $\eta = 1.02$ for different values of ν. If $\nu = 0.5$ no bound on the Frisch elasticity applies, but if $\nu = 0.2$ the maximum value on the Frisch elasticity compatible with the existence of equilibrium is 0.828. This bound drops to 0.292 when $\nu = 0.1$. These bounds are within the micro and macro estimates of the Frisch elasticity, Chetty et al. (2011) recommend a value of the Frisch elasticity for the intensive margin of 0.5.

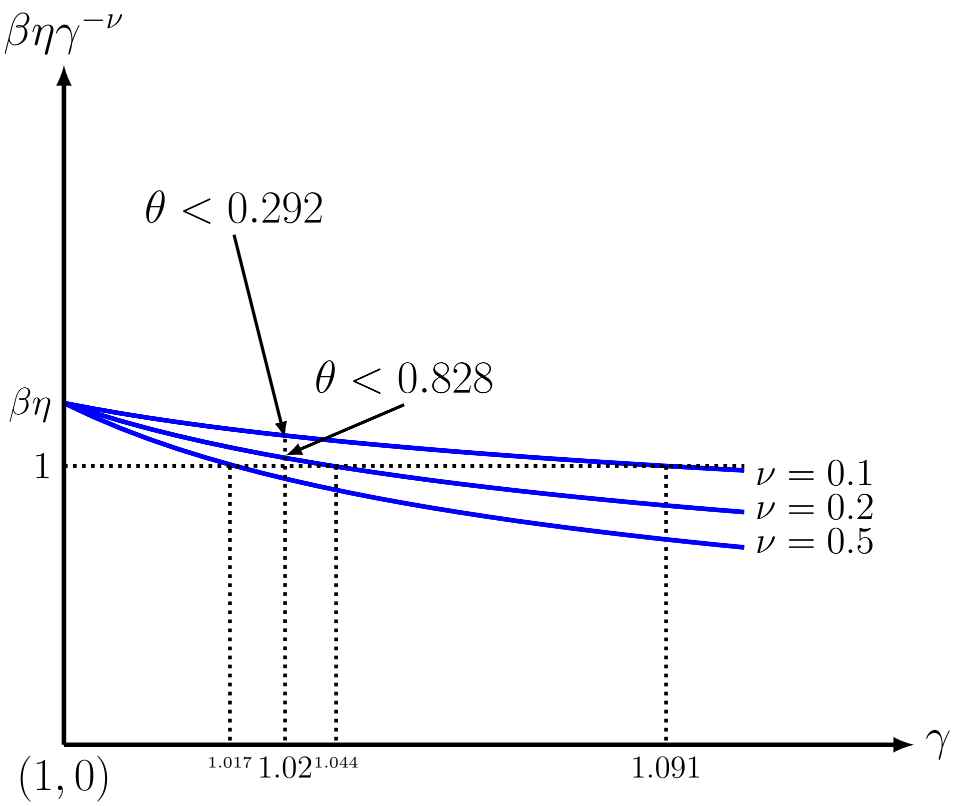


Fig. 5: Numerical example with $\beta = 0.989$ and $\eta = 1.02$.

In addition, the value of this threshold depends on how much it is above or below one $\beta\eta g_h$. The threshold can take a value so high or so low as to make it irrelevant, depending on the values of the parameters involved. However, this bound is relevant for reasonable parameter values. For example, if $\eta = 1.02$ and $g_h = 0.996$, the value of β for which $\beta\eta g_h = 1$ is 0.984, but if $g_h = 1.01$, then $\beta = 0.971$. In the first case, with $\sigma = 2$ and $g = 1.02$, the gross long-term interest rate is $R = 1.052$ and, in the second, $R = 1.066$. Therefore, for empirically plausible values of the parameters, the constraints can be binding.

5 Conclusions

We have explored the implications for infinite horizon macroeconomic models of a large family of utility functions proposed by Boppart and Krusell (2020) which do not restrict the labour-intensive margin to being stationary in the long term, contrary to what is common in the literature.

First, we have found that with BK preferences, long-term economic growth of per capita variables can be driven by the accumulation of productive factors when labour efficiency is declining. The reason is that the income effect caused by the technical reversal could make the labour-intensive margin grow quickly enough to offset it.

Secondly, we have found that under BK preferences some equilibrium paths can emerge that can be paradoxical since they exhibit negative long-term interest rates even when the rate of technical progress is positive and economic agents discount the future or they exhibit positive interest rates even when the rate of technical progress is negative and economic agents capitalize on the present. The reason is that with BK preferences, the growth rate can be positive (resp. negative) if the rate of labour-augmenting technical change is negative (resp. positive).

Finally, we restrict our attention to a MaCurdy utility function, which belongs to the BK family of utility functions and is especially useful for carrying out quantitative exercises since it involves two parameters with a clear economic interpretation: the intertemporal elasticity of substitution and the Frisch elasticity. We show that, given a long-term rate of variation in hours worked per capita, the transversality condition limits the range of values of the elasticity of substitution and the Frisch elasticity compatible with a balanced growth path.

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Table 1: Annual gross growth rates in percentage.

Country	Period	$1+g_h$	$1+g_{ha}$	$1+g_y$
Hungary	1980-2019	0.9903	0.9973	1.0236
Cyprus	1995-2019	0.9915	0.9986	1.0058
Germany	1950-2019	0.9917	0.9980	1.0305
France	1950-2019	0.9918	0.9831	1.0249
Romania	1995-2019	0.9928	0.9984	1.0581
Turkey	1970-2019	0.9931	1.0065	1.0201
Finland	1950-2019	0.9933	1.0013	1.0282
Pakistan	1970-2019	0.9941	1.0042	1.0160
Ireland	1950-2019	0.9942	1.0000	1.0410
Spain	1950-2019	0.9945	1.0019	1.0313
Denmark	1950-2019	0.9954	1.0009	1.0215
Thailand	1970-2019	0.9955	1.0102	1.0344
Iceland	1965-2019	0.9958	1.0038	1.0170
Norway	1950-2019	0.9958	1.0016	1.0396
India	1970-2019	0.9961	1.0096	1.3485
United Kingdon	1950-2019	0.9962	1.0034	1.0222
Belgium	1950-2019	0.9962	1.0021	1.0259
Hong Kong	1960-2019	0.9964	1.0078	1.0361
Italy	1950-2019	0.9967	1.0055	1.0327
Austria	1950-2019	0.9969	1.0021	1.0306
South Africa	2001-2019	0.9969	1.0144	1.0088
Jamaica	1987-2002	0.9970	1.0053	1.0099
Viet Nam	1970-2019	0.9972	1.0092	1.0382
Switzerland	1950-2019	0.9974	1.0010	1.0198
Netherlands	1950-2019	0.9975	1.0027	1.0253
Greece	1951-2019	0.9976	1.0069	1.0307
Slovakia	1990-2019	0.9978	1.0052	1.0222
Sweden	1950-2019	0.9978	1.0035	1.0247
Brasil	1950-2019	0.9982	1.0101	1.0294
Taiwan	1951-2019	0.9983	1.0122	1.0500
Canada	1950-2019	0.9985	1.0048	1.0184
Australia	1950-2019	0.9985	1.0041	1.0201
Japan	1950-2019	0.9986	1.0048	1.0000
Venezuela	1950-2006	0.9991	1.0115	0.9992
Argentina	1950-2019	0.9991	1.0069	1.0353

Country	Period	$1+g_h$	$1+g_{ha}$	$1+g_y$
USA	1950-2019	0.9997	1.0054	1.0185
Malta	1994-2019	0.9998	1.0066	1.0274
Uruguay	1990-2019	1.0000	1.0053	1.0256
New Zeland	1970-2019	1.0000	1.0010	1.0171
Sri Lanka	1970-2019	1.0000	1.0092	1.0283
Czech Republic	1993-2019	1.0008	1.0043	1.0249
Portugal	1950-2019	1.0008	1.0128	1.0350
Chile	1951-2019	1.0009	1.0091	1.0217
Costa Rica	1987-2019	1.0010	1.0072	1.0205
Malaysia	1970-2019	1.0010	1.0145	1.0288
Colombia	1950-2019	1.0011	1.0094	1.0147
Korea. Republic of	1953-2019	1.0013	1.0150	1.0618
Bulgaria	1995-2019	1.0018	1.0161	1.0409
Slovenia	1990-2019	1.0018	1.0064	1.0218
China	1972-2019	1.0018	1.0145	1.0492
Ecuador	1995-2019	1.0019	1.0092	1.0357
Peru	1950-2019	1.0020	1.0142	1.0176
Bangladesh	1970-2019	1.0021	1.0147	1.0191
Myanmar	1970-2019	1.0026	1.0075	1.0382
Poland	1995-2019	1.0032	1.0105	1.0400
Estonia	1995-2019	1.0034	1.0103	1.0543
Russian Federation	1992-2019	1.0038	1.0109	1.0470
Mexico	1950-2019	1.0038	1.0136	1.0134
Cambodia	1993-2019	1.0053	1.0168	1.0402
Israel	1981-2019	1.0055	1.0124	1.0171
Croatia	1995-2019	1.0062	1.0171	1.0407
Philippines	1970-2019	1.0065	1.0183	1.0197
Indonesia	1970-2019	1.0067	1.0198	1.0358
Latvia	1995-2019	1.0069	1.0131	1.0512
Singapore	1960-2019	1.0083	1.0258	1.0493
Dominican Republic	1990-2019	1.0088	1.0215	1.0362
Luxembourg	1970-2019	1.0094	1.0094	1.0294
Lithuania	1995-2019	1.0114	1.0189	1.0551
Trinidad and Tobago	1991-2002	1.0155	1.0241	1.0108

Note: Countries are ordered by the column showing the gross growth rate of hours worked $1+g_h$, $1+g_{ha}$ is the gross growth rate of quality-adjusted hours worked. Hours per capita are average annual hours worked by persons engaged in production (**avh**) multiplied by number of persons engaged in production (**emp**) and divided by population aged 15-64. Quality hours per capita are hours per capita multiplied by the human capital index (**hc**). GDP per capita is output-side real GDP (RGDPO) divided by population. The gross annual rates of change are computed running a regression between years and the logs of the variables, and then the exponential of the estimated coefficient is computed. All variables are from Feenstra et al. (2015) (Penn World Table 10.01) execepting population aged 15-64 which is provided by United Nations (2024).