Meta-preference, endogenous preference formation and dynamic choice

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Abstract

In a dynamic environment, this paper builds a model of layers of meta-preferences which explains endogenous preference formation as a consequence of subjective judgment by the decision maker's current self about welfare of her successor self. The model allows us to describe how much the decision maker is willing to pay for investment in her preference formation. The paper provides a recursive utility representation of the layers of meta-preferences and applies it to the problems of investment in time preference and taste.

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1 Introduction

It is well-acknowledged that preference of an individual is formed endogenously and evolves over time as a result of choice behavior, especially at critical stages of his/her personal development, while the stationary discounted utility model (Koopmans (1960)) is a good description of continuing everyday economic life of an adult in which once developed human nature is not easily changing.

Prominent theoretical works on such endogenous preference formation are about: (i) habit formation in tastes over per-period consumption, including rational addiction (Ryder Jr and Heal (1973), Iannaccone (1986), Becker and Murphy (1988), Rozen (2010)); (ii) habit formation in time discounting (Shi and Epstein (1993)); (iii) investment in time preference (Becker and Mulligan (1997)).

These studies explain preference formation in the standard rational choice framework which maintains the condition of dynamic consistency for a single individual. For other approaches, one can raise for example (i) explaining endogenous preference formation as a cultural coordination (Bowles (1998), Bisin and Verdier (2001)); (ii) explaining endogenous preference formation from evolutionary viewpoints (see Samuelson (2001) for survey); (iii) handling the problem of dynamic inconsistency arising due to disagreements between successive selves about how to evaluate the evolution (Bernheim et al. (2021)).

In this paper, we ask what is driving endogenous preference formation in the rational choice framework maintaining dynamic consistency. This is somehow a *trivial* question, since it should be ultimately determined by some "time-0" preference. Indeed, in the existing models of endogenous preference formation along this line the "time-0" preference determines the whole life course and her lifetime welfare, and any endogenous transitions are attributed to non-separability of such "time-0" preference. But is endogenous preference formation just about non-separability of intertemporal consumption?

This paper aims at understanding an involved nature of "time-0" preference. We claim that there is a logical tension when we try to think of such ultimate preference. Consider the following assertion to motivate.

> I want to acquire taste for complex music.

Why does she want to acquire taste for complex music, and why is she willing to pay for an investment on acquisition? If her current self does not like complex music, the choice to be made after acquisition of the taste does not look optimal from the viewpoint of the current self. Why does she invest? If her current self already likes complex music, there is no point in trying to acquire taste for it. How can this be told in a consistent manner? What form of dynamic programming problem is she solving?

The same type of problem arises in a consumption-saving context, when we say

> I want to become more patient.

If her current self is not patient, the choice to be made after becoming patient will be suboptimal (over-saving) from the viewpoint of the current self. Why does she invest on becoming patient? If her current self is already patient, there is no point in trying to become patient.

The examples suggest that we should make it explicit the layers of *meta-preferences*. Although her current self has no taste for complex music, she wants to acquire taste for it because her current self makes a *subjective welfare judgement* that the life after acquisition of the taste will be happier, and that's what she wants. In other words, her current self has altruism toward her successor self.[1]

Such altruism is non-paternalistic in the sense that the current self cares about *welfare* of the successor self and it is consistent with what the successor self maximizes. It is paternalistic, however, in the sense that the current self subjectively rescales the welfare of the successor self and chooses which preference to give to the successor self.[2] This is indeed what our main theorem conveys.

The formal idea of meta-preference appears in a recent independent paper by Pivato (2023), asking a rather more philosophical question of how the ultimate and universal description of a decision maker should be, along the literature of universal type space (Mertens and Zamir (1985), Brandenburger and Dekel (1993)). It considers how a rational decision maker could normatively evaluate her life, a pair of outcome she receives and her own preference, by relfecting about herself, where such normative evaluation together with an

[1]Hayashi and Takeoka (2022) takes a different approach to the above-noted tension in endogenous preference formation. It explains the tension as a self-control problem in which the current self is tempted to maintain the status-quo preference in the stationary manner while she has a normative preference for changing tastes.

[2]This is formally parallel to how a parent has altruism toward her child so that she invest on the child's personality development, as in Doepke and Zilibotti (2017).

outcome must be again evaluated by her higher-order preference, and so on, and her reflection should repeat forever if she is "rational." It is more concerned with a methodological issue on the existence and well-definedness of an infinite hierarchy, which is a timeless one and includes no intermediate consumption. Thus the domain we build can be seen as a dynamic counterpart of theirs and it is meant to be a rather positive model.

In the dynamic context, we build a recursive domain of life courses and meta-preferences, in which a life course starting at a given period is a triple of current consumption, life course starting at the next period and preference to give to the successor self, and a meta-preference is defined over such triples, and so on. In other words, meta-preference is defined as a *state variable* or *capital*.

Modelling such meta-preference in the dynamic context allows us to formulate how much the current self is willing to pay for which preference to give to the successor self. This allows us to argue what preferences are "costly," which is familiar in our everyday life wording, whereas it is senseless in the existing framework in which a single preference is just there.

As a part of the domain construction, we impose two axioms on meta-preferences: (i) current consumption does not affect the ranking over pairs of life course starting at the next period and preference to give to the successor self, which emphasizes that non-separability of intertemporal consumption is not the issue; and (ii) the dynamic consistency axiom which guarantees that the successor self indeed maximizes the preference being chosen by the current self. We show that such layers of meta-preferences have a recursive utility representation, which allows the use of dynamic programming technique.

In actual dynamic choice problems, even without direct non-separability between current consumption and future ones, our model allows that the choice of current consumption activity indirectly affects preferences in the future, because such path-dependence is attributed to *technology or institution* as there is in general a technological or institutionally induced trade-off or complementarity between current consumption activity and investment in preference for the next period.

2 The layers of meta-preferences and life courses

Time is discrete and finite, it runs from 0, 1 to T. Let C be the set of per-period consumption alternatives, which is compact and metric.

In the presentation below, all of construction of the choice domain, building the space of meta-preferences and imposition of the axioms are made *in tandem*. This contrasts to the existing framework in which we first formulate the choice domain, then define preference or system of preferences over the choice domain, and then impose axioms on the preference or the system of preferences.

In what follows, given a compact metric space Y, let $\mathcal{K}(Y)$ denote the set of compact subsets of Y, which is again a compact metric space with respect to the Hausdorff metric.

Definition 1 The layers of meta-preferences and life courses $(\mathcal{Z}_T, \Theta_T, \cdots, \mathcal{Z}_0, \Theta_0)$, where Θ_t refers to the set of meta-preferences at Period t and $\mathcal{Z}_t$ refers to the set of life courses starting at Period t, is defined recursively as follows.

Set of life courses starting at Period T is given by $\mathcal{Z}_T = C$, which is compact metric.

Set of preferences at Period T, denoted Θ_T, is a closed subset of $\mathcal{K}(\mathcal{Z}_T^2)$ which consist of complete, transitive and continuous preference relations over $\mathcal{Z}_T$. Thus Θ_T is compact metric.

Set of life courses starting at Period $T-1$ is given by $\mathcal{Z}_{T-1} = C \times \mathcal{Z}_T \times \Theta_T$, which is compact metric.

Set of meta-preferences at Period $T-1$, denoted Θ_{T-1}, is a closed subset of $\mathcal{K}(\mathcal{Z}_{T-1}^2)$ which consist of complete, transitive and continuous preference relations over $\mathcal{Z}_{T-1}$ satisfying Axiom 1 and 2 below. Thus Θ_{T-1} is compact metric.

$\cdots$

Set of life courses starting at Period t is given by $\mathcal{Z}_t = C \times \mathcal{Z}_{t+1} \times \Theta_{t+1}$, which is compact metric.

Set of meta-preferences at Period t, denoted Θ_t, is a closed subset of $\mathcal{K}(\mathcal{Z}_t^2)$ which consist of complete, transitive and continuous preference relations over $\mathcal{Z}_t$ satisfying Axiom 1 and 2 below. Thus Θ_t is compact metric.

$\cdots$

Set of life courses starting at Period 0 is given by $\mathcal{Z}_0 = C \times \mathcal{Z}_1 \times \Theta_1$, which is compact metric.

Set of meta-preferences at Period 0**,** denoted Θ_0, is a closed subset of $\mathcal{K}(\mathcal{Z}_0^2)$ which consist of complete, transitive and continuous preference relations over $\mathcal{Z}_1$ satisfying Axiom 1 and 2 below. Thus Θ_0 is compact metric.

To understand, at each period t, the decision maker is to rank a triple $z_t = (c_t, z_{t+1}, \theta_{t+1})$, an element of $\mathcal{Z}_t = C \times \mathcal{Z}_{t+1} \times \Theta_{t+1}$, where c_t is current consumption, z_{t+1} is life course starting at the next period and θ_{t+1} is preference to give to the successor self in the next period. Her current type θ_t is identified as a ranking $\succsim_{\theta_t}$ over such triples, that is, as an element of $\mathcal{K}((\mathcal{Z}_t)^2) = \mathcal{K}((C \times \mathcal{Z}_{t+1} \times \Theta_{t+1})^2)$. Thus we write

$$z_t \succsim_{\theta_t} z_t'$$

and

$$(c_t, z_{t+1}, \theta_{t+1}) \succsim_{\theta_t} (c_t', z_{t+1}', \theta_{t+1}')$$

in an interchangeable manner because $z_t = (c_t, z_{t+1}, \theta_{t+1})$ and $z_t' = (c_t', z_{t+1}', \theta_{t+1}')$.

The axioms imposed at each step of construction are as follows.

Axiom 1 (**Current Consumption Separability**): For each $t = 0, \cdots, T-1$, for all $\theta_t \in \Theta_t$, $c_t, c_t' \in C$ and for all $(z_{t+1}, \theta_{t+1}), (z_{t+1}', \theta_{t+1}') \in \mathcal{Z}_{t+1} \times \Theta_{t+1}$, it holds

$$\begin{aligned} & (c_t, z_{t+1}, \theta_{t+1}) \succsim_{\theta_t} (c_t, z_{t+1}', \theta_{t+1}') \\ \iff & (c_t', z_{t+1}, \theta_{t+1}) \succsim_{\theta_t} (c_t', z_{t+1}', \theta_{t+1}'). \end{aligned}$$

Axiom 2 (**Dynamic Consistency**): For each $t = 0, \cdots, T-1$, for all $\theta_t \in \Theta_t$, $c_t \in C$ and $\theta_{t+1} \in \Theta_{t+1}$, for all $z_{t+1}, z_{t+1}' \in \mathcal{Z}_{t+1}$, it holds

$$\begin{aligned} & z_{t+1} \succsim_{\theta_{t+1}} z_{t+1}' \\ \iff & (c_t, z_{t+1}, \theta_{t+1}) \succsim_{\theta_t} (c_t, z_{t+1}', \theta_{t+1}). \end{aligned}$$

Current Consumption Separability makes it clear that endogenous preference formation here is NOT about non-separability of intertemporal consumption and there is a pure preference over preferences in the future. Dynamic Consistency guarantees that the successor self indeed maximizes the preference being chosen by the current self as intended.

3 Recursive utility representation

The theorem below establishes recursive utility representation of the layers of meta-preferences.

Theorem 1 A sequence $(\mathcal{Z}_T, \Theta_T, \cdots, \mathcal{Z}_0, \Theta_0)$ meets Definition 1 if and only if (i) and (ii) below hold:

(i) For each $t = 0, 1, \cdots, T$ and $\theta_t \in \Theta_t$, there is a continuous function $U_{\theta_t} : \mathcal{Z}_t \to \mathbb{R}$ which represents $\succsim_{\theta_t}$.

(ii) Given $(U_{\theta_t})_{\theta_t \in \Theta_t, t=0,1,\cdots,T}$, there exist a family of functions $(\phi_{\theta_t\theta_{t+1}})_{\theta_t \in \Theta_t, \theta_{t+1} \in \Theta_{t+1}, t=0,1,\cdots,T-1}$ and $(W_{\theta_t})_{\theta_t \in \Theta_t, t=0,1,\cdots,T}$, where each $\phi_{\theta_t\theta_{t+1}} : U_{\theta_{t+1}}(\mathcal{Z}_{t+1}) \to \mathbb{R}$ is monotone and each $W_{\theta_t} : C \times \bigcup_{\theta_{t+1} \in \Theta_{t+1}} \phi_{\theta_t\theta_{t+1}}(U_{\theta_{t+1}}(\mathcal{Z}_{t+1})) \to \mathbb{R}$ is monotone in the second argument, such that

$$U_{\theta_t}(z_t) = W_{\theta_t}\left(c_t, \phi_{\theta_t\theta_{t+1}}\left(U_{\theta_{t+1}}(z_{t+1})\right)\right)$$

holds for all $t = 0, 1, \cdots, T-1$, $\theta_t \in \Theta_t$ and $z_t = (c_t, z_{t+1}, \theta_{t+1}) \in \mathcal{Z}_t$.

Proof. Sufficiency of (i) and (ii) is straightforward.

Necessity of (i): For each $t = 0, 1, \cdots, T$ and $\theta_t \in \Theta_t$, by Debreu (1964) there is a continuous representation of $\succsim_{\theta_t}$, which is denoted by $U_{\theta_t} : \mathcal{Z}_t \to \mathbb{R}$ which represents $\succsim_{\theta_t}$. Note that Debreu's theorem applies since compact metric space is second countable. Do this for all $\theta_t \in \Theta_t$ and $t = 0, 1, \cdots, T$, and fix a family of representations $(U_{\theta_t})_{\theta_t \in \Theta_t, t=0,1,\cdots,T}$,

Necessity of (ii): Given the above, by Current Consumption Separability, for each θ_t there exist functions $U^\star_{\theta_t} : \mathcal{Z}_{t+1} \times \Theta_{t+1} \to \mathbb{R}$ and $W_{\theta_t} : C \times U^\star_{\theta_t}(\mathcal{Z}_{t+1} \times \Theta_{t+1}) \to \mathbb{R}$ such that

$$U_{\theta_t}(c_t, z_{t+1}, \theta_{t+1}) = W_{\theta_t}(c_t, U^\star_{\theta_t}(z_{t+1}, \theta_{t+1}))$$

holds for all $(c_t, z_{t+1}, \theta_{t+1}) \in \mathcal{Z}_t = C \times \mathcal{Z}_{t+1} \times \Theta_{t+1}$, and W_{θ_t} is monotone in the second argument.

By Dynamic Consistency, $U^\star_{\theta_t}(\cdot, \theta_{t+1})$ and $U_{\theta_{t+1}}(\cdot)$ are ordinally equivalent representation of $\succsim_{\theta_{t+1}}$ over $\mathcal{Z}_{t+1}$, there is a monotone transformation $\phi_{\theta_t\theta_{t+1}} : U_{\theta_{t+1}}(\mathcal{Z}_{t+1}) \to \mathbb{R}$, depending on both θ_t and θ_{t+1}, such that

$$U^\star_{\theta_t}(z_{t+1}, \theta_{t+1}) = \phi_{\theta_t\theta_{t+1}}\left(U_{\theta_{t+1}}(z_{t+1})\right)$$

holds for all $z_{t+1} \in \mathcal{Z}_{t+1}$.

Summing up, it holds

$$U_{\theta_t}(z_t) = W_{\theta_t}\left(c_t, \phi_{\theta_t\theta_{t+1}}\left(U_{\theta_{t+1}}(z_{t+1})\right)\right)$$

for all $z_t = (c_t, z_{t+1}, \theta_{t+1}) \in \mathcal{Z}_t$.

■

The function $\phi_{\theta_t\theta_{t+1}}$ is interpreted as describing how the current self with type θ_t rescales the welfare of the successor self with type θ_{t+1}. When $\phi_{\theta_t\theta_{t+1}}$ is greater it is interpreted that θ_t and θ_{t+1} are familiar with each other. The function W_{θ_t} is the standard recursive aggregator as in Koopmans (1960), while it is dependent on type θ_t.

On uniqueness of the representation, the following claim is immediate from ordinal equivalence. It should be noted that an outside observer cannot distinguish between how the scale of $U_{\theta_{t+1}}$ is conceived for the decision maker and how her current meta-preference θ_t evaluates the successor preference θ_{t+1} by means of rescaling via $\phi_{\theta_t\theta_{t+1}}$, since both are subjective elements of the meta-preference.

Proposition 1 Suppose that $(\widetilde{U}_{\theta_t})_{\theta_t\in\Theta_t, t=0,1,\cdots,T}$, $(\widetilde{\phi}_{\theta_t\theta_{t+1}})_{\theta_t\in\Theta_t,\theta_{t+1}\in\Theta_{t+1}, t=0,1,\cdots,T-1}$ and $(\widetilde{W}_{\theta_t})_{\theta_t\in\Theta_t, t=0,1,\cdots,T}$ give a representation of $(\mathcal{Z}_T, \Theta_T, \cdots, \mathcal{Z}_0, \Theta_0)$ as in Theorem 1.

Then there exist monotone transformations $(F_{\theta_t})_{\theta_t\in\Theta_t, t=0,1,\cdots,T}$, where $F_{\theta_t} : U_{\theta_t}(\mathcal{Z}_t) \to \mathbb{R}$ for each $\theta_t \in \Theta_t$, $t = 0, 1, \cdots, T-1$, such that

$$\widetilde{U}_{\theta_t}(z_t) = F_{\theta_t}(U_{\theta_t}(z_t))$$

holds for all $z_t \in \mathcal{Z}_t$, and

$$W_{\theta_t}\left(c_t, \phi_{\theta_t\theta_{t+1}}\left(U_{\theta_{t+1}}\right)\right) = F_{\theta_t}^{-1}\left(\widetilde{W}_{\theta_t}\left(c_t, \widetilde{\phi}_{\theta_t\theta_{t+1}}\left(F_{\theta_{t+1}}(U_{\theta_{t+1}})\right)\right)\right)$$

holds for all $c_t \in C$ and $U_{\theta_{t+1}} \in U_{\theta_{t+1}}(\mathcal{Z}_{t+1})$, for all $t = 0, 1, \cdots, T-1$ and $\theta_t \in \Theta_t$, $\theta_{t+1} \in \Theta_{t+1}$.

4 Dynamic programming formulation

The representation theorem above allows us to formalize dynamic choice problems with endogenous preference formation in the form of dynamic programming.

To explain, we define the recursive domain of choice problems as follows.

Set of choice problems at Period T is given by $\mathcal{B}_T = \mathcal{K}(C)$, which is compact metric.

Set of choice problems at Period $T-1$ is given by $\mathcal{B}_{T-1} = \mathcal{K}(C \times \mathcal{B}_T \times \Theta_T)$, which is compact metric.

$\cdots$

Set of choice problems at Period t is given by $\mathcal{B}_t = \mathcal{K}(C \times \mathcal{B}_{t+1} \times \Theta_{t+1})$, which is compact metric.

$\cdots$

Set of choice problems at Period 0 is given by $\mathcal{B}_0 = \mathcal{K}(C \times \mathcal{B}_1 \times \Theta_1)$, which is compact metric.

We can extend the layers of meta-preferences to the recursive domain of choice problems, that is, for each $t = 0, 1, \cdots, T$ and $\theta_t \in \Theta_t$, we write

$$B_t \succsim^*_{\theta_t} B'_t$$

for $B_t, B'_t \in \mathcal{B}_t$ if and only if

$$z_t \succsim_{\theta_t} z'_t$$

where z_t and z'_t are the maximal elements in B_t and B'_t respectively according to $\succsim_{\theta_t}$ which are unique up to indifference.

We can extend the corresponding recursive utility representation to the recursive domain of choice problems. That is, for each $t = 0, 1, \cdots, T$ and $\theta_t \in \Theta_t$, define the value function $V_{\theta_t} : \mathcal{B}_t \to \mathbb{R}$ by

$$V_{\theta_t}(B_t) = \max_{z_t \in B_t} U_{\theta_t}(z_t)$$

for each $B_t \in \mathcal{B}_t$, so that V_{θ_t} represents $\succsim^*_{\theta_t}$.

Then the system of value functions $(V_{\theta_t})_{\theta_t \in \Theta_t, t=0,1,\cdots,T}$ satisfies the Bellman equation

$$V_{\theta_t}(B_t) = \max_{(c_t, B_{t+1}, \theta_{t+1}) \in B_t} W_{\theta_t}\left(c_t, \phi_{\theta_t \theta_{t+1}}\left(V_{\theta_{t+1}}(B_{t+1})\right)\right)$$

for all $B_t \in \mathcal{B}_t$, for all $t = 0, 1, \cdots, T-1$ and $\theta_t \in \Theta_t$.

5 Applications

5.1 Investment in time preference

Here we follow the idea of investment in time preference due to Becker and Mulligan (1997), in which the current self wants to make her successor self more patient because of the subjective welfare judgement that the continuation lifetime discounted utility is larger under more patience.

Here a meta-preference is summarized in the form of discounter factor, which is understood as *patience capital* (Doepke and Zilibotti (2017), Hayashi (2020)). Thus, let $\Theta = [\underline{\theta}, \overline{\theta}]$ with $0 < \underline{\theta} < \overline{\theta} < 1$. Assume that there is an infinite time horizon and the environment is time-invariant for simplicity.

Assume that the aggregator $W_\theta(\cdot, \cdot)$ is linear in the second argument, taking the form $W_\theta(c, V) = u(c) + \theta V$, where $u : \mathbb{R}_+ \to \mathbb{R}$ is the per-period utility function which is assumed to be time-invariant. Also assume that the transformation function takes the form $\phi_{\theta\theta'}(U) = U$ for simplicity.

Let $a \in \mathbb{R}_+$ denote an amount of physical capital (or asset) holding. Given physical capital a and patience capital θ, let $Y(a, \theta)$ denote the set of feasible triples of current consumption, physical capital holding for the next period and patience capital for the next period. There is typically a trade-off between current consumption and investment in patience capital, as well as between current consumption and investment in physical capital.

Then the dynamic programming problem is given in the form of the Bellman equation

$$V(a, \theta) = \max_{(c, a', \theta') \in Y(a, \theta)} \{u(c) + \theta V(a', \theta')\},$$

where $V : \mathbb{R}_+ \times [\underline{\theta}, \overline{\theta}] \to \mathbb{R}$ is the value function. Since $0 < \underline{\theta} < \overline{\theta} < 1$, the Bellman equation has a unique solution under the standard regularity condition.

In the continuous-time setting, Hayashi (2020) shows that there is a downward-sloping curve in the (a, θ)-space such that if the initial (a, θ) falls in the upper-right side of the curve the individual invests more on her patience capital, leading to more saving of physical capital, which leads to more investment on the patience capital, and so on, and if the initial (a, θ) falls in the lower-left side of the curve the individual invests less on her patience capital, leading to decay in the patience capital, which leads to less saving and decrease in the physical capital, and so on.

5.2 Investment in taste

There are two goods. One is generic and taste for it is time-invariant, so that the per-period utility of consumption c is simply given by $u(c)$. The other is specific and taste for it depends on "taste capital," denoted θ, so that the per-period utility of its consumption x is given by $v(\theta, x)$. An alternative interpretation is that such specific good is labour hour and θ explains disutility of labour.

Assume again that there is an infinite time horizon and the environment is time-invariant for simplicity. Assume that the aggregator $W_\theta(\cdot, \cdot)$ is linear in the second argument, taking the form $W_\theta((c, x), V) = u(c) + v(\theta, x) + \beta V$. Also assume again that the transformation function takes the form $\phi_{\theta\theta'}(U) = U$ for simplicity.

Let $a \in \mathbb{R}_+$ denote an amount of physical capital (or asset) holding. Given physical capital a and taste capital θ, let $Y(a, \theta)$ denote the set of feasible triples of current consumption, physical capital holding for the next period and taste capital for the next period.

Then the dynamic programming problem is given in the form of the Bellman equation

$$V(a, \theta) = \max_{(c, x, a', \theta') \in Y(a, \theta)} \{u(c) + v(\theta, x) + \beta V(a', \theta')\}$$

where $V : \mathbb{R}_+ \times \mathbb{R}_+ \to \mathbb{R}$ is the value function.

The model allows us to describe that there is technological or institutionally induced trade-offs between current consumption of the generic good and acquisition of taste for the specific good, which is described as a nature of set $Y(a, \theta)$. In the case of trade-off, the model allows us to describe how much the acquisition of taste is costly and how mush the decision maker is willing to pay for the acquisition, which are measure by the generic good. The existing habit formation models (Iannaccone (1986), Ryder Jr and Heal (1973), Becker and Murphy (1988), Rozen (2010)), in which consumption of some specific good deepens the taste for it, explain the deepening by means of non-separability of consumption preference across periods. In our model, such deepening is rather explained as the case of technological complementarity.

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